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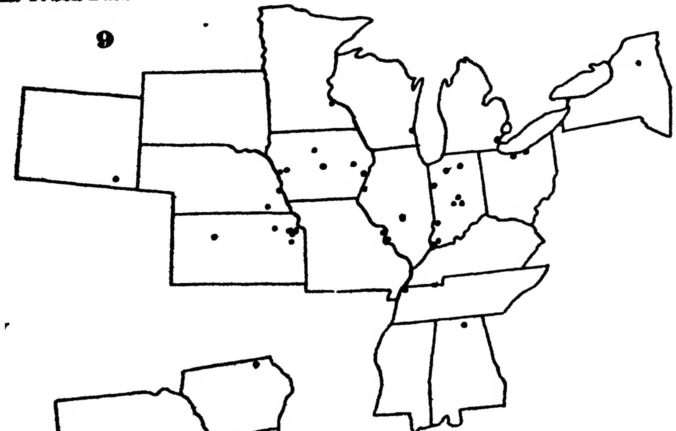
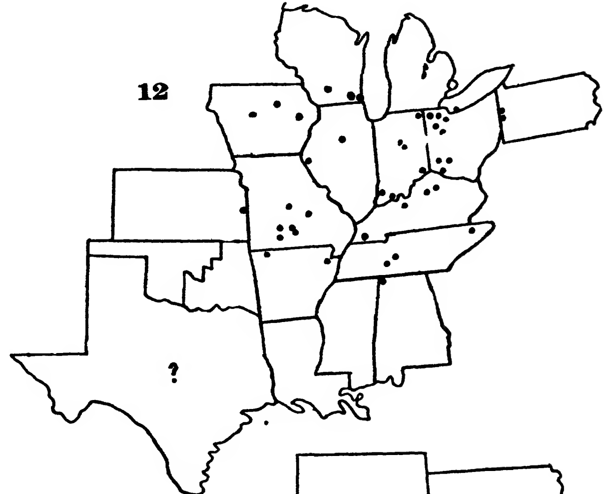
CONTENTS OF VOLUME II.

PLATE V.

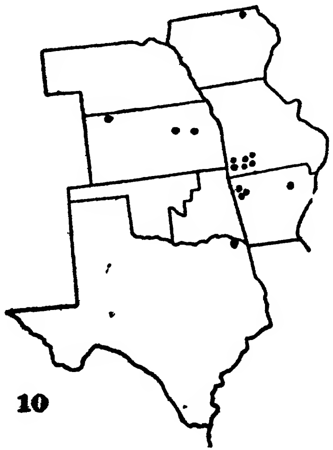
9



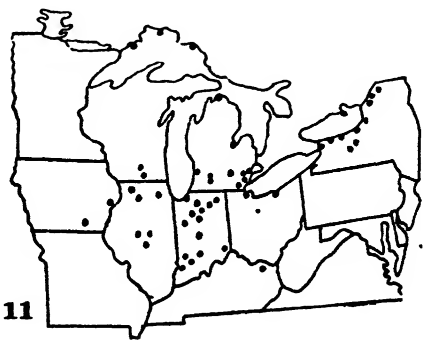
12



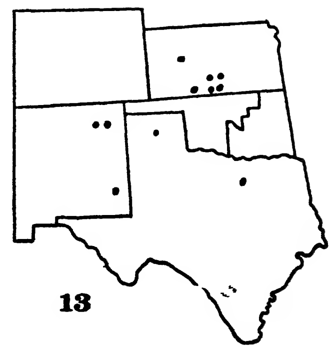
10



11



13



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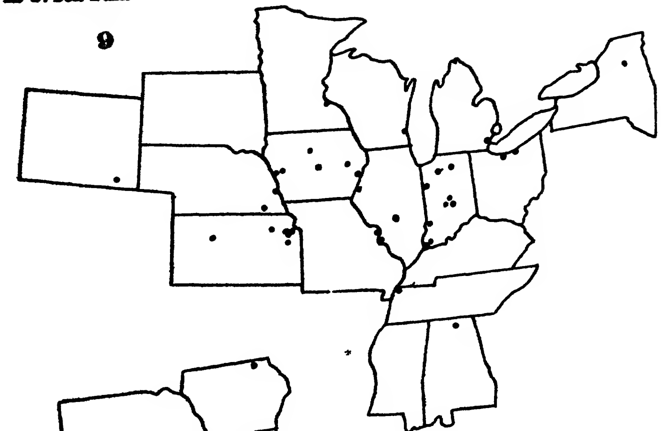
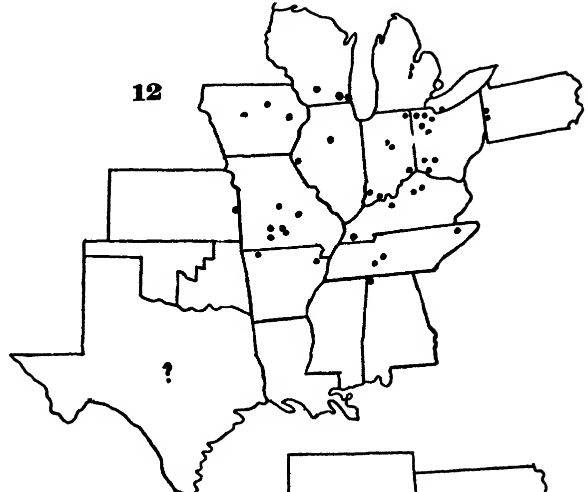
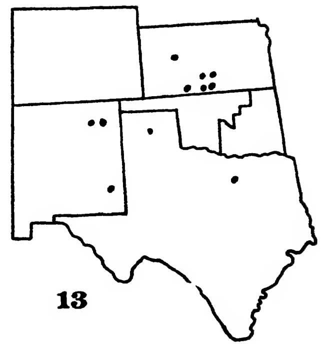
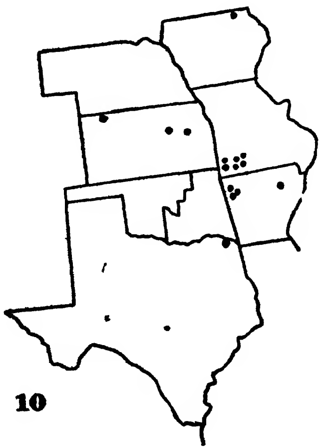


12

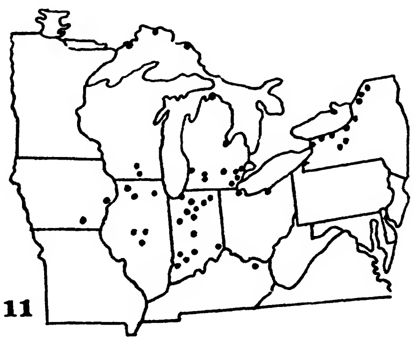




10



11



13

PLATE V.

Distribution of *Cambarus*.

FIG. 9.—*C. immunis* and *C. immunis spinirostris* (excepting questionable Mexican locality).

FIG. 10.—*C. neglectus*.

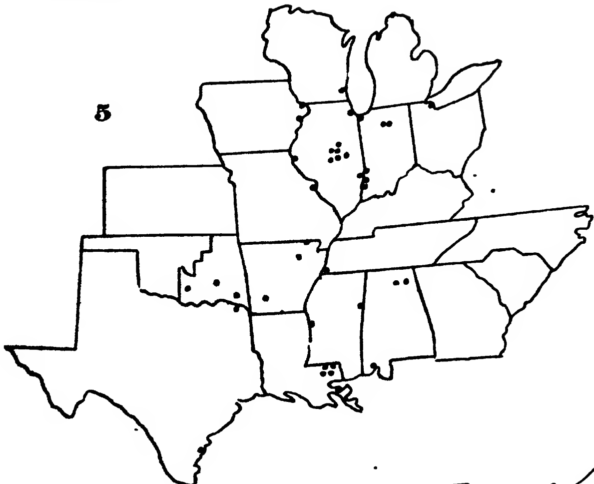
FIG. 11.—*C. propinquus* and *C. propinquus sanbornii*.

FIG. 12.—*C. rusticus*.

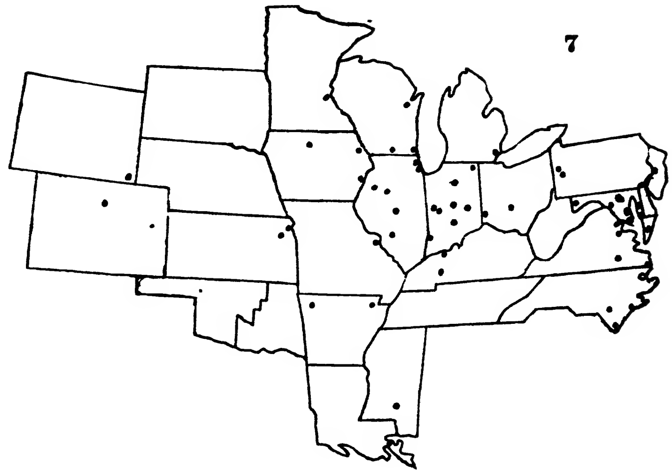
FIG. 13.—*C. simulans*.

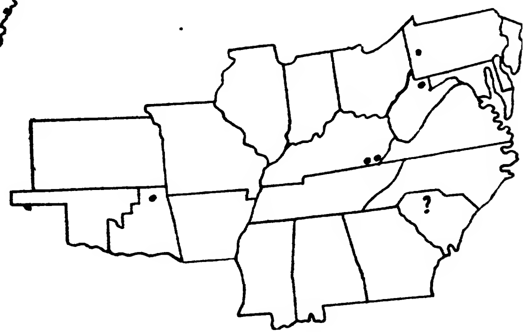
PLATE IV.

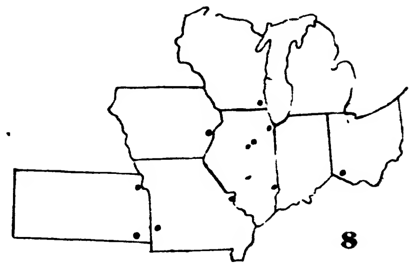
5



7







8

PLATE IV.

Distribution of *Cambarus*.

Fig. 5.—*C. blandingii acutus.*

Fig. 6.—*C. carolinus.*

Fig. 7.—*C. diogenes* and *C. diogenes ludoviciana.*

Fig. 8.—*C. gracilis.*

PLATE III.

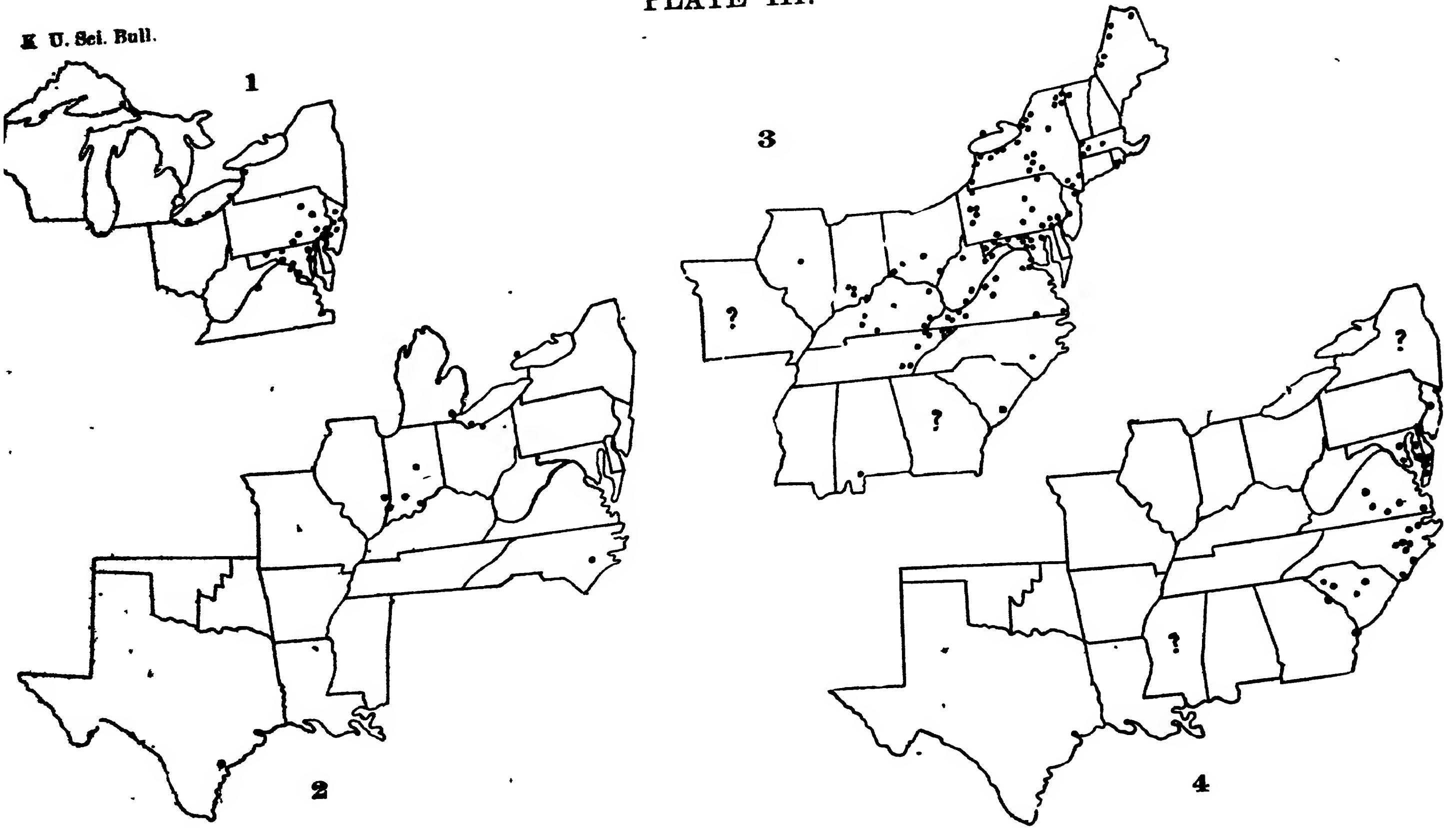


PLATE III.

Distribution of *Cambarus*.

FIG. 1.—*C. affinis.*
FIG. 2.—*C. argillicola.*
FIG. 3.—*C. bartonii*, *C. bartonii longirostris*, and *C. bartonii robustus.*
FIG. 4.—*C. blandingii.*

PLATE II.

PLATE II.

PLATE II.

Distribution of *Cambarus virilis*.

PLATE I.

See page 67.

PLATE I.

Conjugation of *Cambarus affinis*, from photograph by Dr. R. W. Shufeldt.

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CONTENTS:

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ON MONOIDS.

BY JOHN N. VAN DER VRIES.

(Continued.)

WE shall hereafter consider in each section all monoids that have the same lines of kinds III and IV, and shall subdivide the monoids in these sections according to the lines of kind I and the multiple lines of kind II which are found on them. When we write a line of kind I(1, 2), we mean the particular line of kind I which is a single line on the superior cone and a double line on the inferior cone.

Monoids having a double point, say the point (0, 0, 1, 0), *on a line* xy *of kind* III.

a). If the monoid has a double line of kind II, say the line xz, its equation will be of the form

$$x^2u_2 + xzv_2 + z^2w_2 + xzsv_1 + z^2sw_1 + x^2su_1 = 0.*$$

Every plane through the double line and one of the seven other lines of the monoid will in general cut a transversal out of the monoid, no two of the seven lines lying in general in one plane with the double line.

b). If the monoid has a second double line of kind II, say the line yz, the equation of the monoid will be of the form

$$x^2y^2 + xyzu_1 + z^2u_2 + z^2sv_1 + xyzs = 0.$$

The inferior cone breaks up into the plane z and a quadric cone. This monoid has two ordinary lines in addition to the three lines xy, xz, and yz. A plane through either double line and one of the two ordinary lines or the line of kind III cuts out a transversal from the monoid. The monoid thus has in general six transversals in addition to the five lines through the vertex.

* Hereafter u, v, w and t with subscripts will denote homogeneous functions of x and y of degrees equal to the subscripts, unless otherwise designated.

c). If the monoid has a simple line of kind I(1, 2), say the line xz, its equation will be of the form

$$xu_3 + zv_3 + z^2u_2 + x^2su_1 + xzsv_1 + z^2sw_1 = 0.$$

The monoid will have eight ordinary lines in addition; it will not in general have any transversals.

d). If the monoid has two single lines of kind I(1, 2), say xz and yz, the equation of the monoid will be of the form

$$xyu_2 + zu_3 + v_2z^2 + xyzs + u_1z^2s = 0.$$

The inferior cone breaks up into a plane and a quadric cone; the plane meets the monoid in four lines passing through the vertex. There are six ordinary lines on the monoid besides the three lines xy, xz, and yz. In general, there is no case in which three and only three of the nine lines on the monoid lie in one plane, and therefore there is in general no transversal on a monoid of this kind.

e). If the monoid has three simple lines of kind I(1, 2), the inferior cone will break up into three planes not passing through one and the same line. The intersections of these three planes are simple lines on the superior cone. The equation of this monoid will then be of the form

$$u_4 + u_3z + u_2z^2 + u_1v_1w_1s = 0;$$

where u_1, v_1 and w_1 are homogeneous functions of x, y and z of degree 1. One of the planes of the inferior cone meets the superior cone in four lines, of which two are lines of kind I, and other two the double line which is the line of kind III on the monoid. The other two planes meet the superior cone in four lines, of which two are lines of kind I and two are ordinary lines on the monoid. This accounts for all twelve lines on the monoid.

f). If the monoid has a simple line of kind I(1, 2), say yz, in addition to a double line, say xz, of kind II, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + z^2v_2 + xyzs + z^2sv_1 = 0.$$

The inferior cone breaks up into a plane and a quadric cone. A plane through the double line and the line of kind III cuts out of the monoid a transversal which passes through the double point on the line of kind III and intersects the double line at the point at which the scrolar tangent plane coincides with this cutting plane. A plane through the double line and the line of kind I cuts out of the monoid an ordinary line in addition. There are three other ordinary lines on the monoid, and no two of these will in general lie in the same plane with the double line. There are thus in general four transversals on this monoid.

g). If the monoid has two single lines of kind I(1, 2), in addition to the double line of kind II, the equation of the monoid will be of the form

$$u_4 + u_3z + u_2z^2 + u_1v_1w_1s = 0.$$

This monoid differs from case *e*) above in the fact that one of the double edges of the inferior cone is also a double edge of the superior cone. Two of the planes of the inferior cone meet the monoid in the double line, a line of kind I, and an ordinary line, whereas the third plane of the inferior cone meets the monoid in the line of kind III counting twice and two lines of kind I. A plane through the double line and either of the ordinary lines or the line of kind III cuts a transversal from the monoid.

The monoid can have no third line of kind I(1,2).

h). If the monoid has a line of kind I(1,2) in addition to two double lines of kind II, the equation will be similar to that in case *g*) above; two of the double edges of the inferior cone will however be double edges on the superior cone. One of the planes of the inferior cone meets the monoid in the two double lines, whereas the other two each cuts the monoid in a double line and a line of kind I or a line of kind III. This monoid has no transversals.

i). If the monoid has a simple line of kind I(1,3), say xz, its equation will be of the form

$$xu_3 + zv_3 + z^2u_2 + x^3s + x^2zs + xz^2s = 0.$$

The inferior cone breaks up into three planes having the line xy in common. One of these planes meets the monoid in the line xy counting twice, the line xz and an ordinary line through the vertex, whereas the other two planes each cuts out of the monoid three ordinary lines in addition to the lines of kind III. This monoid can only have a transversal if three lines, one in each of the three planes of the inferior cone, lie in one plane.

j). If the monoid has a double line of kind I(2,3), say xz, its equation will be of the form

$$x^2u_2 + xzv_2 + z^2w_2 + x^3s + x^2zs + xz^2s = 0.$$

The inferior cone breaks up into three planes which pass through one line, viz., xz. One of these planes meets the monoid in the lines xy and xz each counting twice, whereas the other two each cuts out the line xz twice and two ordinary lines. If two of these ordinary lines lie in the same plane with the line of kind III, there will be a transversal passing through the double point on the line of kind III.

k). If the monoid has a line xz of kind I(1,3) and a line of kind I(1,2), its equation will be of the form

$$xyu_2 + z^2v_2 + zv_3 + xz^2s = 0.$$

The inferior cone breaks up into a double plane and a single plane, the triple edge of the inferior cone being an ordinary edge on the superior cone, and the double edge of the superior cone being an ordinary edge on the inferior cone. The double plane meets the superior cone in the lines xz and yz, and in two additional lines, which are also lines of kind I(1,2) on the monoid. The single plane meets the monoid in the line xy counting twice, the line xz, and an ordinary line $x(ay+bz)$. This monoid will not have any transversals.

Monoids having two double points, say the points (0, 0, 1, 0) *and* (0, 1, 0, 0), *on the lines* xy *and* xz *of kind* III.

a). If the monoid has a double line of kind II, say the line yz, its equation will be of the form

$$xyzu_1 + z^2u_2 + x^2y^2 + z^2u_1s + yzv_1s + xy^2s = 0.$$

The plane containing the lines of kind III cuts the monoid in addition in a conic which passes through the vertex and the two double points, whereas the planes that pass through the double line and one of the lines of kind III intersect the monoid in addition in a transversal. There are four ordinary lines on the monoid in addition to the three lines xy, xz, and yz. There are therefore, in general, six transversals on the monoid; there will be another when three of the ordinary lines or two of these and a line of kind III lie in one plane.

b). If the monoid has a simple line of kind I(1,2), say yz, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + z^2v_2 + yzsv_1 + z^2sw_1 + xy^2s = 0.$$

The monoid has six ordinary lines on it and will have a transversal whenever three of the nine lines of the monoid lie on one plane.

c). If the monoid has two simple lines of kind I(1,2), the equation of the monoid will be of the form

$$u_3 + u_2v_1s = 0;$$

where u_3, u_2 and v_1 are homogeneous functions of x, y and z of degrees equal to their subscripts. This monoid does not in general have any transversals.

d). If the monoid has three simple lines of kind I(1, 2,) the equation of the monoid will be of the form

$$u_3 + u_1v_1w_1s = 0;$$

where u_3, u_1, v_1 and w_1 are homogeneous functions of x, y and z of degrees equal to their subscripts. Two of the three planes of the inferior cone each cuts out a line of kind III twice and two lines of kind I, whereas the third plane cuts out two lines of kind I and two ordinary lines, thus making up the twelve lines of the monoid. There are no transversals.

e). If the monoid has a simple line of kind I(1,2), say yz, and a double line of kind II, say (ax + by, cx + dz), the equation of the monoid will be of the form

$$z(ax+by)(exy+fxz+gyz)+(cx+dz)xy+$$
$$s[z(ax+by)^2+y(cx+dz)^2-(ax+by)(cx+dz)(cy+az)]=0.$$

A plane through the two lines of kind III meets the monoid in addition in a conic which passes through the vertex and the two double points; a plane through the double line and either of the two lines of kind III meets the monoid in addition in a transversal which passes through the double point on the line of kind III; and a plane through the double line and either of the two ordinary lines meets the monoid in an additional transversal. If, however, we take the monoid to have for its equation

$$(exy+fxz+gyz)(ax+by)(cx+dz)+$$
$$s[(ax+by)z^2+(cx-dz)yz]=0,$$

where xy and $(ax+by)(cx+dz)$ are the lines of kind III, xz the line of kind II, and yz the line of kind I, the superior cone breaks up into a quadric cone and two planes. In this case the monoid has an additional transversal, for the plane through the two lines of kind III meets the monoid in addition in an ordinary line through the vertex and a transversal.

f). If the monoid has a double line of kind I(2,3), say the line yz, the equation of the monoid will be of the form

$$x^2y^2+u_2z^2+xyzu_1+y^2zs+yz^2s=0.$$

The inferior cone breaks up into three planes that pass through one line. The superior cone has three double edges, of which two are ordinary edges and the third a triple edge on the inferior cone. The plane y cuts the line yz twice out of the monoid and touches the monoid along the line xy, the plane z cuts the line yz twice out of the monoid and touches the monoid along the line xz, and the third plane of the inferior cone cuts out the line yz twice and two ordinary lines. There are in general no transversals on the monoid.

Monoids having three double points on lines of kind III.

a). If this monoid has a double line of kind II, the superior cone has four double lines and must break up. If we call the plane x the single component of the superior cone, xy, xz, and xu_1 (where u_1 is a linear homogeneous function of y and z), the lines of kind III, and yz the double line of kind II, the equation will be of the form

$$x^2u_2+xyzu_1+xv_2s+yzu_1s=0;$$

where u_2 and v_2 are homogeneous quadratic functions of y and z. The plane x meets the monoid in the lines xy, xz, xu_1 and a transversal

xs; the three planes y, z and u_1 each intersect the monoid in the line yz twice, a line of kind III, and a transversal. A plane through the double line and either of the two ordinary lines also meets the monoid in a transversal; the monoid thus has six transversals.

b). If the monoid has a line of kind I(1, 2), the superior cone has three double edges which are simple edges on the inferior cone and a simple edge which is a double edge on the inferior cone. The monoid has four ordinary lines on it and has in general no transversals.

c). If the monoid has two lines of kind I(1, 2), the inferior cone must break up into a quadric cone and a plane. The equation of the monoid will then be of the form

$$u_4 + u_2u_1s = 0;$$

where u_4, u_2 and u_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. The single plane of the inferior cone meets the monoid in four lines, of which two are the lines of kind I and two are the two ordinary lines necessary to make up the twelve. This monoid has no transversals.

d). If the monoid has three lines of kind I(1, 2), the inferior cone breaks up into three planes not having a line in common. The equation of the monoid will then be of the form

$$u_4 + u_1v_1w_1s = 0;$$

where u_4, u_1, v_1 and w_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. Each plane of the inferior cone intersects the monoid in a line of kind III and two lines of kind I. There are no transversals.

e). If the monoid has a line of kind I(1, 3) the equation is of the form

$$u_4 + u_3z + u_2z^2 + u_1z^3 + z^4 + v_1w_1t_1\,s = 0;$$

where v_1, w_1 and t_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. Each of the three planes of the inferior cone meets the monoid in the line of kind I, the line of kind III counting twice and an ordinary line on the monoid. There are no transversals.

f). If the monoid has a double line of kind I(2, 3), the equation of the monoid will be of the form

$$u_1v_3 + v_1w_1t_1s = 0;$$

where u_1, v_1, w_1, v_3 and t_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. There are of course no other lines on the monoid passing through the vertex; there is however one transversal, and it passes through all three double points.

Monoids having four lines of kind III.

This monoid cannot have a double line of kind II, for this would necessitate the superior cone to break up into components of which two at least are planes. One of these planes would meet the inferior cone in a double line and two single lines, that is, four lines in all, and would therefore form part of it. The monoid would therefore break up.

a). If the monoid has a line of kind I(1, 2), the superior cone breaks up into a plane and a cubic cone that has a double edge. The intersections of the cubic component of the superior cone and the plane and the double edge on the cubic component are single edges on the inferior cone; and an ordinary edge of the cubic component of the superior cone is a double edge on the inferior cone. The plane of the superior cone cuts out of the monoid the three lines of kind III and a transversal which passes through the three double points on these lines.

Monoids having a double point, say (0, 0, 1, 0), *on a line of kind* IV(3, 1).

a). If it has a double line, say xz, of kind II, its equation will be of the form

$$x^2u_2+xzv_2+x^2u_1s+xzv_1s+z^2w_1s=0.$$

The superior cone breaks up into a cubic cone that has a double edge and a plane that passes through this double edge. The inferior cone has a double edge at the double edge of the superior cone and an ordinary edge at the triple edge of the superior cone. The plane of the superior cone cuts out of the monoid the double line, an ordinary line, and a transversal. There are five ordinary lines on the monoid, and no two of them lie in general in the same plane with the double line; there are therefore, in general, five transversals, and they all cross the double line.

b). If the monoid has a second double line of kind II, say the line yz, the equation of the monoid will be of the form

$$x^2y^2+xyzu_1+xyzs+z^2sv_1=0.$$

The superior cone breaks up into a quadric cone and two planes passing through the same edge of the quadric cone and the inferior cone into a plane and a quadric cone. Each of the two planes of the superior cone cuts out the line xy, a double line, and a transversal. There is one ordinary line on the monoid and therefore two more transversals, each crossing this ordinary line and one of the two double lines.

c). If the monoid has a line of kind I(1, 2), say the line xz, the equation of the monoid will be of the form

$$xu_3 + zv_3 + x^2su_1 + xzsv_1 + z^2sw_1 = 0.$$

There are seven ordinary lines on this monoid and in general no transversals.

d). If the monoid has two lines of kind I(1, 2), say xz and yz, the equation of the monoid will be of the form

$$xyu_2 + zu_3 + z^2su_1 + xyzs = 0.$$

The inferior cone breaks up into a quadric cone and a plane which meets the monoid in four lines passing through the vertex There are five ordinary lines on this monoid and in general no transversals.

The monoid cannot have three lines of kind I(1, 2), for the inferior cone would then break up into three planes, of which one would have to meet the superior cone in the triple edge and two single edges, and would therefore be a component of it.

e). If the monoid has a line of kind I(1, 2), say yz, in addition to a double line of kind II, say xz, the equation will be of the form

$$x^2yu_1 + xzu_2 + xyzs + z^2v_1s = 0.$$

Both cones of the monoid break up into a plane and a cone of order one less. The plane of the superior cone intersects the monoid in the double line, an ordinary line, and a transversal. There are two additional ordinary lines on the monoid, and a plane through either of them and the double line also cuts a transversal from the monoid.

f). If the monoid has a line of kind I(1, 3), say xz, the equation will be of the form

$$xu_3 + zv_3 + x^3s + x^2zs + xz^2s = 0.$$

The inferior cone breaks up into three planes which have a simple edge of the superior cone in common, and one of these three planes also passes through the triple edge of the superior cone. The plane x cuts out the line xy thrice and the line xz once, and the other planes of the inferior cone each cuts out of the monoid three ordinary lines in addition to the line xz. The monoid does not in general have any transversals.

g). If the monoid has a line of kind I(1, 3), say xz, and a line of kind I(1, 2), say the line yz, the equation of the monoid will be of the form

$$xyu_2 + zv_3 + xz^2s = 0.$$

The inferior cone breaks up into a double plane and a single plane. The double plane meets the monoid in the lines xy, xz, and two other lines, which are also lines of kind I(1, 2). Therefore, if the monoid has one line of kind I(1, 2) in addition to the line of kind I(1, 3), it also has two other such lines. This monoid has no transversals.

h). If the monoid has a double line of kind II, say the line xz, and a line of kind I(1, 3), say the line yz, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + yz^2s = 0.$$

The superior cone breaks up into a cubic cone having a double edge and a plane passing through this double edge and the inferior cone into a double plane and a single plane. The single plane which is a component of the superior cone intersects the monoid in the line xy counted once, the line xz counted twice, and a transversal. The double plane of the inferior cone meets the monoid in the double line xz counted twice, the line yz counted once, and another line which is a line of kind I(1, 2). The monoid has four lines and one transversal.

Monoids having a double point, say (0, 0, 1, 0), *on a line of kind* IV(3, 1), *and a double point, say* (0, 1, 0, 0), *on a line of kind* III (2, 1).

a). If the monoid has a double line of kind II, say the line yz, the equation of the monoid will be of the form

$$x^2y^2 + xyzu_1 + xy^2s + z^2sv_1 + yzsw_1 = 0.$$

The plane x intersects the monoid in the line xy, the line xz, an ordinary line through the vertex and a transversal; the plane y cuts out the line xy once, the line yz twice, and a transversal; and the plane z intersects the monoid in the line xz once, the line yz twice, and a transversal. There are two additional ordinary lines on the monoid; a plane through the double line and either of these cuts a transversal from the monoid. The monoid has six lines and three transversals.

b). If the monoid has a double line of kind II and a single line of kind I(1, 2), the equation of the monoid will be of the form

$$u_1v_1w_2 + u_2w_1s = 0;$$

where u_1, v_1, w_1, u_2 and w_2 are homogeneous functions of x, y and z of degrees equal to the subscripts. One of the two planes of the superior cone intersects the monoid in the line of kind IV and in the double line, and therefore intersects the monoid also in a transversal; the other plane of the superior cone intersects the monoid in addition to a transversal in the line of kind IV, the single line of kind I, and an ordinary line which is the line necessary to make up the twelve lines on the monoid.

c). If the monoid has a line of kind I(1, 3), say the line yz, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + y^2zs + yz^2s = 0.$$

The plane x, which with a cubic cone constitutes the superior cone of the monoid, intersects the monoid in three lines through the vertex and in a transversal. The three planes into which the inferior cone breaks up each meets the monoid in four lines, and therefore touches the monoid at the vertex. The monoid has in general only one transversal. The lines of the monoid of course lie in the three planes of the inferior cone.

d). If the monoid has a line of kind I(1,2), say the line yz, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + xy^2s + yzsv_1 + z^2sw_1 = 0.$$

There are five ordinary lines on the monoid, one of which lies in the same plane as the lines xy and xz; this plane cuts out a transversal. There is in general no other transversal.

e). If the monoid has two lines of kind I(1,2), the equation of the monoid will be of the form

$$u_1v_3 + u_2v_1s = 0;$$

where u_1, u_2, v_1 and v_3 are homogeneous functions of x, y and z of degrees equal to their subscripts. The double and triple edges of the superior cone are ordinary edges on the inferior cone, and the double edges on the inferior cone are ordinary edges on the superior cone. The plane of the inferior cone meets the monoid in the two lines of kind I and two ordinary lines. The remaining ordinary line necessary to make up the twelve lines of the monoid is the remaining intersection of the quadric component of the inferior cone and the cubic component of the superior cone. The plane of the superior cone meets the monoid in a transversal; there is in general no other transversal.

Monoids having a line of kind IV(3,1) *and two lines of kind* III(2,1).

This monoid cannot have a double edge of kind II, for the superior cone that has a triple edge and three double edges breaks up into three planes through a line and a fourth plane not through this line; the inferior cone having one double edge of the superior cone as a double edge and the two other double edges as simple edges, must contain one of the planes of the superior cone as factor. This causes the monoid to break up.

a). If the monoid has a line of kind I(1,2), the superior cone must break up into a quadric cone and two planes that have an edge of the quadric cone in common. The double edge of the inferior cone is an ordinary edge on the quadric cone and the triple edge on the superior cone is an ordinary edge on the quadric cone. These four

lines count for nine lines of the monoid. Each plane of the superior cone intersects the monoid in the line of kind IV, a line of kind III, an ordinary line on the monoid, and a transversal. The monoid has two transversals, each passing through the double point on the line of kind IV and one of the double points on the lines of kind III. The twelfth line on the monoid is the residual intersection of the quadric cone and the cubic cone. The equation of the monoid will be of the form

$$u_1v_1w_2 + u_3s = 0;$$

where u_1, u_3, v_1 and w_2 are homogeneous functions of x, y and z of degrees equal to their subscripts.

Monoids having two lines of kind IV(3, 1), *say* xy *and* xz.

a). If the monoid has a double line of kind II, say yz, the equation of the monoid will be of the form

$$x^2yz + xy^2s + yzsu_1 + z^2sv_1 = 0.$$

The superior cone breaks up into a double plane and two single planes. The inferior cone has the two triple edges of the superior cone as single edges and the double edge of the superior cone as a double edge. The double plane of the superior cone meets the monoid in the two lines of kind IV, a transversal and a line which, being a double line on the superior cone and a single line on the inferior cone, is a line of kind III on the monoid. The single planes of the superior cone intersect the monoid in the double line counted twice, a line of kind IV, and a transversal. This monoid thus has four lines on it and four transversals, for a plane through the double line and the line of kind III also cuts a transversal out of a monoid.

b). If the monoid has a line of kind I(1, 2), say the line yz, the the equation of the monoid will be of the form

$$x^3y + x^2zu_1 + xy^2s + yzsv_1 + z^2sw_1 = 0.$$

The superior cone breaks up into a double plane and a quadric cone. The two triple edges on the superior cone are ordinary edges on the inferior cone, and the double edge on the inferior cone is a single edge on the superior cone. The double plane meets the inferior cone in the two lines of kind IV and a line of kind III. The plane x thus cuts out of the monoid three lines to double points and a transversal passing through these double points. There is in general no other transversal. The remaining two lines necessary to make up the twelve lines of the monoid are the residual intersections of the quadric and the cubic cones.

c). If the monoid have a line of kind I(1, 3), say the line yz, the equation of the monoid will be of the form

$$x^3y + x^2zu_1 + y^2zs + yz^2s = 0.$$ —

The superior cone breaks up into a double plane and a quadric cone and the inferior cone into three planes that have an edge of the quadric cone in common. The double plane of the superior cone intersects the monoid in the two lines of kind IV and a line of kind III, which is therefore a line to a double point. As in the previous cases, there is one transversal, and it passes through all three double points. Two of the single planes of the inferior cone intersect the monoid in the line of kind IV counted thrice and the line of kind I, whereas the third plane intersects the monoid in the line of kind I, the line of kind III counted twice, and an ordinary line.

d). If the monoid has two lines of kind I (1,2), the equation will be of the form

$$u_1^2v_2 + u_2w_1s = 0;$$

where u_1, u_2, v_2 and w_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. The triple lines on the superior cone are ordinary lines on the inferior cone and the double lines on the inferior cone are ordinary lines on the superior cone The double plane of the superior cone intersects the monoid in the two lines of kind IV and a line of kind III; the monoid thus has another double point. As in previous cases, there is a transversal passing through these three double points. The monoid thus has five lines on it and one transversal.

Monoids having a line of kind IV (4, 1), *say the line* xy.

a). If the monoid has a double line of kind II, say the line xz, the equation of the monoid will be of the form

$$x^2u_2 + x^2su_1 + xzsv_1 + z^2sw_1 = 0.$$

The superior cone breaks up into a double plane and two single planes, all having the line xy in common. The quadruple line on the superior cone is an ordinary line on the inferior cone, and a double edge on the superior cone is a double edge on the inferior cone. The double plane of the superior cone intersects the monoid in the line xy, the line xz counted twice, and a transversal. Each of the two single planes of the superior cone intersects the monoid in the line xy, two ordinary lines and a transversal. A plane through the double line and each of these four ordinary lines of the monoid also cuts a transversal out of the monoid. The monoid thus has six lines and seven transversals.

b). If the monoid has a second double line of kind II, say the line yz, the equation of the monoid will be of the form

$$x^2y^2 + xyzs + z^2su_1 = 0.$$

The superior cone breaks up into two double planes and the inferior cone into a quadric cone and a plane. The inferior cone has the

quadruple line of the superior cone as an ordinary edge and the double lines as double edges, Each of the double planes of the superior cone cuts out of the monoid a double line, the line of kind IV and a transversal. The monoid has three lines and two transversals.

c). If the monoid has a line of kind I(1, 2), say the line xz, the equation of the monoid will be of the form

$$xu_3+x^2u_1s+xzsv_1+w_1z^2s=0.$$

The plane x intersects the monoid in the line xy, the line xz counted twice, and a transversal. Each of the other three planes of the superior cone intersects the monoid in the line of kind IV and two ordinary lines (thus making up the twelve lines on the monoid), and also a transversal. There are thus eight lines on the monoid, and in general only four transversals, and each of these four passes through the double point on the line of kind IV.

d). If the monoid has a second line of kind I(1, 2), say the line yz, its equation will be of the form

$$xyu_2+z^2u_1s+xyzs=0.$$

The plane x intersects the monoid in the line xy, the line xz counted twice, and a transversal; the plane y intersects the monoid in the line xy, the line yz counted twice, and a transversal; and each of the other two planes of the superior cone intersects the monoid in the line xy and two ordinary lines through the vertex in addition to the transversal. The monoid thus has seven lines and in general only four transversals.

e). If this monoid has a double line of kind II, say the line xz, and a line of kind I(1, 2), say the line yz, its equation will be of the form

$$x^2yu_1+xyzs+v_1z^2s=0.$$

The double plane of the superior cone intersects the monoid in the line of kind IV, the line of kind II counted twice, and a transversal; each of the two single planes cut out the line of kind IV, the line of kind I counted twice, and a transversal; and the other single plane intersects the monoid in the line of kind IV, two ordinary lines, and a transversal. A plane through the double line and the ordinary line which does not lie in the plane of the inferior cone also cuts a transversal from the monoid. This monoid has five lines on it and four transversals.

Monoids having a line of kind IV(4, 1), *say* xy, *and a line of kind* III(2, 1), *say* xz.

a). If the monoid has a double line of kind II, say the line yz, its equation will be of the form

$$x^2y^2+u_1z^2s+v_1yzs+xy^2s=0.$$

The superior cone breaks up into two double planes. One of these intersects the monoid in the line xy, the line yz counted twice, and a transversal, and the other cuts out the lines xy and xz and a transversal, in addition to a line which is a second line of kind III. A plane through the double line and either of the lines of kind III will cut out an additional transversal that passes through the double point on the line of kind III. This monoid has four lines and four transversals.

b). If the monoid has a line of kind I(1,2), say the line yz, its equation will be of the form

$$x^2yu_1 + xy^2s + v_1yzs + w_1z^2s = 0.$$

The superior cone breaks up into a double plane and two single planes. The double plane intersects the monoid in the lines xy and xz and a transversal in addition to a line which, being double on the superior cone and single on the inferior cone, is a line of kind III. Each of the other two planes of the superior cone intersects the monoid in three lines through the vertex and a transversal. There are thus six lines on the monoid and in general only three transversals.

Monoids having a double line of kind III(2,3), *say the line* xy.

a). If the monoid has a line of kind I(1,2), say the line xz, its equation will be of the form

$$xu_3 + zv_3 + u_1x^2s + v_1xzs = 0.$$

The plane x intersects the monoid in the line xy thrice and the line xz. Each plane through the line xy and one of the four ordinary lines of the monoid cuts out a transversal. The monoid thus has six lines on it and in general just four transversals, and these four all pass through the triple point on the line of kind III.

b). If the monoid has a line of kind I(1,3), say the line xz, its equation will be of the form

$$xu_3 + zv_3 + x^3s + x^2zs = 0.$$

The inferior cone breaks up into a double plane and a single plane. The single plane intersects the monoid in three ordinary lines in addition to the line of kind I. A plane through the double line and either the line of kind I or one of the ordinary lines cuts a transversal from the monoid. This monoid thus has six lines and four transversals passing through the triple point on the line of kind III.

Monoids having a double line of kind III, *say the line* xy, *and a line of kind* III(2,1), *say the line* xz.

a). If the monoid has a line of kind I(1,2), say the line yz, the equation of the monoid will be of the form

$$x^2yu_1 + xzu_2 + yzsv_1 + xy^2s = 0.$$

The plane x intersects the monoid in the line xy counted twice, the line xz, and a transversal. Each plane through the double line and one of the two ordinary lines on the monoid intersects the monoid in addition in a transversal. The monoid thus has five lines and three transversals.

b). If the monoid has a line of kind I(1, 3), say the line yz, its equation will be of the form

$$x^2yu_1 + xzu_2 + y^2zs = 0.$$

The plane of the inferior cone intersects the monoid in the line yz, the line xz counted twice, and an ordinary line of the monoid. The plane of the superior cone cuts out of the monoid the line xy twice, the line xz, and a transversal. The double plane of the inferior cone cuts out the line xy thrice and the line yz once. A plane through the double line and the ordinary line also cuts out a transversal. This monoid has four lines and two transversals.

Monoids having a triple point on a line of kind III *and two double points on lines of kind* III.

a). If the monoid has a line of kind I(1, 2), its equation will be of the form

$$u_2u_1v_1 + v_2w_1s = 0;$$

where u_2, u_1, v_2, v_1 and w_1 are homogeneous functions of x, y and z of degrees equal to the subscripts. Here u_1 and v_1 have an edge of u_2 in common. The triple edge of the superior cone is a double edge on the inferior cone, the two double edges of the superior cone are single edges on the inferior cone, and the second double edge of the inferior cone is a simple edge on the superior cone. There are no other lines on the monoid. Each of the two single planes of the superior cone intersects the monoid in a transversal.

Monoids having a double line of kind III, *say the line* xy, *and a double point on a line of kind* IV(3, 1).

a). If the monoid has a line of kind I(1, 2), say the line yz, its equation will be of the form

$$x^3y + x^2zu_1 + xy^2s + yzsv_1 = 0.$$

The superior cone breaks up into a double plane and a quadric cone and the inferior cone into a plane and a quadric cone. There is one ordinary line on the monoid. The double plane cuts out the line of kind IV, the double line, and a transversal. A plane through the double line and the ordinary line also cuts out a transversal. The monoid thus has four lines and two transversals.

b). If the monoid has a line of kind I(1, 3), say the line yz, its equation will be of the form

$$x^3y + x^2zu_1 + y^2zs = 0.$$

The superior cone breaks up into a double plane and a quadric cone; the inferior cone breaks up into a double plane and a single plane. The double plane of the superior cone intersects the monoid in the double line, the line of kind IV, and a transversal. There are only three lines on the monoid and one transversal.

Monoids having a line of kind IV(4, 1), *say the line* xy, *and a line of kind* IV(3, 1), *say the line* xz.

a). If the monoid has a line of kind I(1, 2), say the line yz, the equation will be of the form

$$x^3y + xy^2s + v_1yzs + w_1z^2s = 0.$$

The triple plane of the superior cone intersects the monoid in the line xy, the line xz, and a third line which, being a triple line on the superior cone and an ordinary line on the inferior cone, is also a line of kind IV; this plane also cuts out a transversal. The single plane of the superior cone also cuts a transversal from the monoid. The monoid thus has four lines and two transversals.

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CONTENTS

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DIPTEROLOGICAL CONTRIBUTIONS.

BY C. F. ADAMS.

FOR the pleasure of studying diptera in the University of Kansas, I have to thank Dr. F. H. Snow, whose interest in things scientific is so well known. To Dr. S. W. Williston I am under deep obligations, for the use of his dipterological library and his collection. To Prof. J. M. Aldrich and Mr. D. W. Croquillet thanks are due for looking up references.

The material reported in this paper comes principally from two localities, Rhodesia, Africa, and western North America. The African material was collected by Mr. F. L. Snow, son of Dr. F. H. Snow, while visiting near Salisbury, Rhodesia. This lot is a very important addition to the University collection, and as I get time and literature more at my command I shall report further concerning it. Most of the American species were collected by expeditions under the direction of Doctor Snow. I have Doctor Williston's consent for including his two new species in this paper.

I. NORTH AMERICAN SPECIES.

MYCETOPHILIDÆ.

Mycetobia marginalis, n. sp.

Female: Black, shining; head black, subshining, tip of palpi yellow; mesonotum black, shining, humeri, lateral and posterior margins, and scutellum with a reddish cast, pile yellow, pleuræ black, mostly shining, halteres brown; abdomen light yellow, last segment wholly, and the preceding with the basal half, blackish; legs light yellow, tips of tarsi fuscous; wings agree very well with those of *M. palipes* Meig., except the auxiliary vein is a little shorter. Length, 3.5 mm.

One specimen; Atherton, Mo. Collected by the writer, May 3, 1901.

Macrocera diluta, n. sp.

Male: Yellow, shining; antennæ, except base, two stripes on occiput, three fascia on mesonotum, the central one joining two narrow ones coming from base of wings, three spots on pleuræ, lower half of metanotum, base of abdominal segments from the third, with hypopygium wholly, small spot on base of middle and posterior coxæ, tips of femora and tibiæ dark brown; wings hyaline, fascia near central part dark brown, a small fuscous spot on anterior margin about midway between tip of anterior branch of third vein and apex of wing, not reaching fourth vein.

Female: Agrees with the male, except that all of the abdominal segments, without the first, have the base dark brown; the subapical spot of wing is larger, crossing the anterior branch of the fourth vein. Length, 5 mm.; antennæ, 7 mm.

A specimen of each sex; Arizona, August. Prof. F. H. Snow.

Ceroplatus apicalis, n. sp.

Male: Head brownish, anterior part of front, two basal joints of antennæ, face and mouth-parts yellow; thorax immaculate, reddish yellow, the black pile very short, except on the sides, pleuræ light yellow, halteres with knobs slightly infuscated; abdomen reddish yellow, base of second, third, fourth, and remainder of apex wholly black; legs light yellow, apical half of tibiæ and tarsi wholly blackish; wings hyaline, smoky towards apex, auxiliary vein ends in the costa about midway between humeral cross-vein and base of third, anterior branch of third ends in costa about midway between tip of first and apex of second branch of third, furcation of fifth almost opposite base of. second. Length, 3.7 mm.

One specimen; Douglas county, Kansas. E. S. Tucker.

Sciophila angulata, n. sp.

Female: Yellow, subshining; head black, anterior part of front, base of antennæ, face and mouth-parts yellow; thorax yellow, mesonotum with three subcoalesced fuscous fascia, the middle one abbreviated behind, the lateral ones in front, pile rather long and yellow, large spot on the pleuræ above middle coxæ brown; abdomen yellow, base of segments brown, pile black; legs light yellow, anterior tibæ shorter than their tarsi;

tips of tarsi fuscous; wings grayish hyaline, marginal cell twice as long as broad, anterior branch of third vein angulate, its apex turned towards base of wing, auxiliary cross-vein slightly beyond middle of marginal cell. Length, 6 mm.

Manitou Park, Colo., August. Prof. F. H. Snow.

It is near *S. flavohirta* Coq., but differs in the markings of the thorax, length of anterior tibiæ, and the angulated anterior branch of the third longitudinal vein.

Sciophila nigricauda, n. sp.

Male: Yellow, subshining; head black, base of antennæ and mouth-parts yellow, sparse pile black; thorax yellow, in places slightly tinged with brown, viewed from before slightly grayish pollinose, pile black, halteres yellow; abdomen yellow, apices of segments, last one wholly black, hypopygium yellow, pile light brown; legs yellow, tarsi, except base, fuscous; wings hyaline, larger veins brown, auxiliary cross-vein near apex of auxiliary vein and just before the middle of the marginal cell, first branch of fourth vein about as long as its prefurca, furcation of the fifth vein takes place just beyond the small cross-vein. Length, 4 mm.

One specimen; Colorado City, Colo., July, 1894. E. S. Tucker.

Tetragoneura nitida, n. sp.

Female: Black, shining; head black, front bearing yellow pile, antennæ dark brown, first two joints and palpi yellowish; mesonotum black, shining, pile yellow, bristles on margins black, scutellum black, bristles yellow. metanotum and pleuræ black, halteres yellow; abdomen wholly shining black, pile yellow; legs yellow, with tip of hind femora, middle and hind tibiæ and all tarsi brown; wings hyaline, tinged with brown on the anterior part, auxiliary vein short, ending free, the furcation of the fourth vein is slightly distad to that of the third. the furcation of the fifth is nearly opposite the junction of the small cross- and fourth veins. Length, 2.7 mm.

One specimen; Atherton, Mo. Collected by writer, May 5, 1901.

Syntemna mutor, n. sp.

Male: Black, subshining; head black, base of third antennal joint and apex of palpi, brownish yellow, antennæ sericeous, front with a few yellowish hairs; mesonotum black, subshining, covered with thin, grayish pollen and yellow pile, a few black bristles on lateral margins near base of wings, scutellum black, bristles concolorous, pleuræ black, bearing sparse yellow pile above front coxæ, metanotum black, halteres yellowish; abdomen in the majority of specimens fulvous except the last segment and hypopygium, which are black, in other specimens the abdomen is largely black, and in one specimen, it is entirely so, pile in all specimens yellow; legs yellow, middle tibiæ on posterior side and tarsi, except base of metatarsi, brown; wings grayish hyaline, tip with a slight blackish tinge, anterior veins dark brown, others lighter, auxiliary vein joins first nearly opposite the base of the fourth, furcation of the fourth and fifth veins opposite the junction of third and small cross-vein.

Female: Agrees with the male, except that the pile of the thorax is almost wholly black, the abdomen is more uniformly fulvous, and the furcation of the fourth vein is a little more proximad than that of the fifth. Length, 3.5 mm.

Many specimens of both sexes; Atherton, Mo. Collected by the writer, during April and May, 1899, 1900, 1901.

Boletina abdominalis, n. sp.

Male: Black, subshining; head and members black, except first antennal joint, which is tinged with yellow, middle ocellus very small; mesonotum black, subshining, covered with yellow pile, which are inclined to arrange themselves into rows, scutellum black, pile yellow, pleurae black, without pile, metanotum black, halteres black; abdomen wholly black, subopaque, hypopygium with a yellowish tinge, pile yellow; legs yellowish, trochanters and tarsi, except base, largely fuscous; wings grayish hyaline, veins fuscous, auxiliary vein joins costa opposite base of third, auxiliary cross-vein slightly before junction of small cross-vein and the fourth, furcation of fifth vein is just distad to the same, and the furcation of the fourth is distad to the junction of the small cross-vein and the third. Length, 3.5 mm.

Atherton, Mo. Collected by the writer, April 13, 1900.

Neoglaphyroptera lineola, n. sp.

Female: Differs from *N. stiata* Will., in the following particulars: The brown of occiput is sharply defined, the center and sides being yellow; pleuræ with a brown spot anterior to and above the middle coxæ, metapleuræ above hind coxæ brown; the last two abdominal segments almost wholly yellow; all trochanters, the posterior coxæ and femora black, the latter with a narrow longitudinal line on the inner and outer sides, yellow; the brown cross-band on outer part of wing is much broader. Length, 4 mm.

One specimen; Kern county, California.

Neoglaphyroptera cuneola, n. sp.

Female: Yellow, shining; vertex with a transverse black line, occiput with a reddish cast and sparse yellow pile, antennæ, except base, dark brown; mesonotum with three shining black stripes, the two lateral ones nearly as broad as long, the middle one wedge-shaped, scarcely reaching the middle of the dorsum, pile yellow, scutellum yellow, with two long yellow bristles; pleuræ black, yellow above anterior coxæ, metanotum black, halteres yellow; abdomen shining black, except narrow lateral margins, apex, and venter, which are yellowish, pile very short and yellow; legs yellow, a small spot on trochanters, extreme tip of posterior femora, tibiæ, and tarsi in large part, fuscous; wings hyaline, a brownish fascia traversing the wing, starting about midway between tip of first vein and apex of wing. Length, 4 mm.

One specimen; Colorado Springs, Colo., August, 1894. Collected by E. S. Tucker.

CULICIDÆ.

Culex affinis, n. sp.

Female: Head and members dark brown, proboscis lighter in the middle; scales of head light brown; thorax brown, mesonotum uniformly covered with brownish yellow scales, pile black, scales of pleuræ mostly white. abdomen brownish scaled, a narrow band at bases of segments white, pile pale yellow, venter white-scaled; coxæ and base of femora pale yellow, distal end of latter dark brown, tibia dark brown with extreme apex and base white; tarsi concolorous with both ends of joints white, which on the front tarsi is indistinct, and the last joint

of hind tarsi wholly white; claws small, simple; veins of wings thinly clothed with light brown scales, petiole of first submarginal cell one-third length of that cell, cross-veins at ends of first and second basal cells the length of the cross-vein at end of second basal cell distant from each other. Length, 3.5 mm.

One specimen; Arizona. Prof. F. H. Snow.

Culex apicalis, n. sp.

Female: Head brown; scales mostly light yellow, some long brown ones; palpi and proboscis wholly brown, antennæ brown, with base lighter, thorax brown with light brown scales, pile black; abdomen dark brown, covered with brownish scales, except those on the posterior margin, which are white, forming on the second and third segments small triangles by projecting forward in the middle, and on the following segments forming narrow bands, venter covered largely with white scales; coxæ and base of femora pale yellow, rest of legs and tarsi wholly brown, tarsal claws small and simple; veins of wings sparsely covered with hairs and scales, petiole of first submarginal cell one-half the length of that cell, the cross-veins at ends of first and second basal cells distant from each other. Length, 4½ mm.

Two specimens; Arizona. Prof. F. H. Snow.

Culex particeps, n. sp.

Male: Head brown, covered with yellowish scales, among which are some pure white ones, few hairs along eyes black; proboscis dark brown, bearing a few yellowish scales; palpi brown, base of each joint white; antennæ brown, lighter at base; thorax brown, bearing yellow and white scales, the latter most prominent on posterior part, pile black; halteres pale with brown knobs; abdomen brown, scales at base of segments white, on remaining part of segments the scales are brown, a few scattering ones yellow, venter almost wholly covered with white scales; fore coxæ brown, others rather pale; femora black, with the posterior side on basal half, and a ring near apex white-scaled; tibiæ black, with a few white scales; tarsi black, with bases white; front and middle tarsal claws toothed, hind ones small and simple; veins of wings

light brown, bearing narrow brown scales, those on the anterior part of wing intermixed with white ones; a spot at the origin of the second vein, the small cross-vein, and a spot beginning at the base of first submarginal and crossing the second submarginal and first posterior cells, clouded with brown; the cross-veins at end of first and second basal cells approximated; petiole of the first submarginal cell one-half the length of the cell.

Female: Agrees with male, except has more long black scales on head, petiole of first submarginal cell one-third the length of that cell; all tarsal claws simple. Length, 8 mm.

One male and six females; Arizona. Prof. F. H. Snow.

CHIRONOMIDÆ.

Ceratopogon dimidiatus, n. sp.

Female: Head black, occiput and cheeks subopaque, front shining, eyes widely separated, face shining, with a yellowish cast, antennæ dark brown, first two joints yellowish, antennal hairs whitish, palpi brown, tip of last joint yellowish; thorax black, mesonotum subshining, faintly whitish pollinose, pleuræ with a longitudinal silvery white pollinose band, halteres light yellow; abdomen black, subshining, sparse, pile yellowish-white; coxæ black, apices yellow, basal half of femora yellow, apical half black, tibiæ wholly black, tarsi yellow, with apices of first, second, third and the last two joints wholly black, metatarsi twice the length of the following joint, last joint of fore tarsi swollen, empodia of all tarsi wanting, front tarsal claws rather small but of equal length, middle and hind tarsi each with a single long claw which bears a rather long basal tooth, the last tarsal joints being partly padded beneath with short, dense hairs; wings hyaline, larger veins dark brown, third vein connected with the first by a cross-vein, the wing in this region with a brown spot; the third vein ends at about four-fifths of the distance from the tip of the first vein to apex of wing; at this point is a second brown spot; fourth and fifth veins furcate opposite the small cross-vein. Length, 3.5 mm.

Four specimens; Grand Canon, Arizona.

STRATIOMYIDÆ.

Euparyphus.—*Table to the species.*

1. Scutellum black, sometimes yellowish at tip; spines largely yellow..... 2
   Scutellum yellow, or red, at most black at base..... 7
2. Femora black, except the tip and sometimes the base..... 3
   Femora yellow or testaceous, except posterior pair, which is variously marked with black..... 5
3. One submarginal cell..... *tetraspilus* Loew.
   Two submarginal cells..... 4
4. Dorsum of abdomen with yellow spots other than on the lateral margins..... *bellus* Loew.
   Dorsum without yellow spots near the center..... *albipilosus*, n. sp.
5. Antennæ black..... 6
   First two antennal joints yellow; (third in the type wanting), *ornatus* Will.
6. Third vein furcate..... *stigmaticalis* Loew.
   Third vein not furcate, discal cell fuscous..... *carbonarius* Giglio-Tos.
7. Eyes thickly pubescent; (sparsely in *elongatulus*, female)..... 8
   Eyes not pubescent; (sparsely in *mutabilis*, male)..... 10
8. Face reddish yellow..... *elongatulus* Will.
   Face largely black, with yellow markings..... 9
9. Abdomen with ten yellow spots..... *decem-maculatus* O. S.
   Abdomen with seven yellow spots..... *septem-maculatus*, n. sp.
10. Thorax greenish, with black stripes..... *elegans* Wied.
    Thorax red, with black stripes..... *tricolor* O. S
    Thorax black, with reddish yellow, or yellow markings..... 11
11. Markings of abdomen largely green..... *limbrocutris* Will.
    Markings of abdomen not green..... 12
12. Third longitudinal vein furcate..... 13
    Third longitudinal vein not furcate..... 15
13. Face shining black, except lateral, subtriangular, whitish pollinose spots, and in some specimens two narrow lines extending downward from base of antennæ..... *mutàbilis*, n. sp.
    Face largely yellow..... 14
14. Apical portion of abdomen reddish yellow..... *apicalis* Coq.
    Apical portion of abdomen not reddish yellow..... *amplus* Coq.
15. First abdominal segment with a yellow spot in the middle, *crucigerus* Coq.
    First abdominal segment without such spot..... 16
16. Venter of abdomen, except lateral margins, wholly black..... *atriventris* Coq.
    Venter not so colored..... 17
17. Abdomen, besides margins, with two yellow spots on either side, *brevicornis* Loew.
    Abdomen with the margins, and an interrupted fascia on the posterior part of the fourth segment, yellow..... *tahoensis* Coq.

The above table is a continuation of the one given by Osten Sacken, and is intended for the reception of species since de-

scribed. *E. nigra* Bigot, from California, is too poorly described to have a place among the known species; the description is fairly complete as far as it goes, but is silent concerning the legs, and says very little about the wings. A few of the species I have not seen and had to rely upon the descriptions.

Euparyphus mutabilis, n. sp.

Male: Head black, frontal triangle yellow, face shining black with lateral subtriangular whitish pruinose spots, in some specimens with two narrow yellow lines extending downward from base of antennæ; inferior occipital orbits whitish pruinose, facial orbits, cheeks and occiput with whitish pile, mouth-parts yellow, antennæ wholly brownish black, eyes sparsely pubescent; thorax black, pile on dorsum pale yellow, on sides almost white, two yellow stripes on each side of middle, which in some specimens meet the broader lateral stripes in front, each of the lateral stripes contains a black spot above base of wing; a narrow yellow fascia on upper part of pleura between humerus and base of wing, a small spot at lower end of mesopleural suture, a larger one on metapleuræ yellow; scutellum yellow, sides at base and tips of spine black, halteres yellow; abdomen black with yellow margin, which sends broad projections inward on each segment, venter black with narrow yellow bands on posterior borders of segments, the one on the second segment usually short but broad; coxæ black, femora black except apices, tibiæ slightly reddish yellow except a narrow brown band near the middle, the tarsi wholly brown, the base of middle and posterior metatarsi testaceous; wings hyaline, stigma and larger veins yellowish, third vein forked.

Female: Front yellow, with a median black line extending from ocellar tubercle to just above base of antennæ where it is produced laterad, frontal orbits on upper half black, which color extends from the superior angle of eye diagonally to near middle of vertex, also narrowly along superior occipital orbits, remaining occipital orbits broadly yellow; the two yellow line of face broader than in the male and slightly divergent below, eyes bare, yellow on sides of thorax more prominent, lateral yellow margin of abdomen more regular in outline, the legs less dark, all metatarsi and base of second tarsal joint yellow; otherwise same as male. Length, 6 mm.

Many specimens of each sex, Lusk, Wyo., collected July, 1895, by W. A. Snow and Hugo Kahl. Two female specimens from Colorado Springs, Colo., collected by E. S. Tucker, during August, 1894, belong to this species, but the yellow abdominal margin is narrower and the black coloring of the front is in predominance.

Euparyphus albipilosus, n. sp.

Male: Head black, facial orbits broadly and inferior occipital orbits narrowly white pruinose and white pilose, antennæ situate on yellow spots, black, first and second joints yellow on their adjacent sides, mouth-parts yellow, eyes sparsely pubescent; thorax black, pile white, dorsum with two short, narrow, whitish yellow lines, lateral lines abbreviated anteriorly and interrupted behind the suture so as to form two spots, one just before the suture and the other on the posterior angle of mesonotum, a strip runs from humerus to and under the wing and narrowly onto the sides of the metathorax, an isolated spot low down on the pteropleura; scutellum black, spines yellowish, with black apices, halteres whitish yellow; abdomen black, yellowish margin narrow, projecting inward from posterior angles of second, third and fourth segments, venter black tinted with yellow in the middle of the segments; coxæ yellowish, brownish black at base, femora black, with base and apex, tibiæ except tinge of brown near middle, fore metatarsi at base, first and second joints of middle and hind tarsi whitish yellow; wings hyaline, large veins and stigma yellowish, third vein furcate.

Female: Front reddish yellow, median black line broadly expanded just above antennæ and almost reaching the eyes, frontal orbits on upper half and superior occipital orbits black, the latter slightly tinged with red, area around the antennæ, a small spot along the eye opposite antennæ, and two small conical spots on face above oral margin, yellow; facial and inferior occipital orbits white pruinose and white pilose; thorax without spot in front of suture; markings on pleuræ almost pure white, hind femora and tibia almost wholly black; veins and stigma brown; in other respects similar to male. Length, 5.5 mm.

Three specimens: Two females, collected by Prof. F. H. Snow, during August, 1902, near Flagstaff, Ariz.; and one male, from Colorado Springs, Colo., collected by E. S. Tucker, August, 1894.

Euparyphus septem-maculatus, n. sp.

Male: Head black, frontal triangle black with two minute white pruinose spots at apex, face black, with a subtriangular yellow spot on either side, facial and inferior occipital orbits narrowly white pruinose, mouth-parts brown, antennæ black, eyes thickly pubescent; thorax black, pile whitish yellow, two narrow yellow lines on dorsum do not reach beyond suture, lateral stripes broad, extend onto the humeri and are interrupted behind suture, a vertical spot anterior and parallel to and a second spot at inferior end of the mesopleural suture; scutellum yellow, narrow margin of base and tips of spines black, halteres yellow; abdomen black with three yellow spots on each margin, the first, on second segment, small, the second and third oblique, broad and narrow, respectively, and on the third and fourth segments, the second projecting onto the anterior angles of the fourth segment, a yellow triangular spot on apex of fifth segment and extends onto posterior margin of fourth segment; venter black, except short yellow bands on central portion of segments; coxæ black, femora black, except tips, tibiæ, first and second joints of fore tarsi, all joints, except the fourth, of the middle and hind tarsi yellow; wings hyaline, large veins and stigma yellow, basal, discal and submarginal cells slightly tinged with yellow, third vein furcate. Length, 8.5 mm.

One specimen; Palo Alto, Cal., September, 22, 1891. Leland Stanford Jr. University. (Lot 25, sub. 8.)

Euparyphus limbrocutris Williston.

Euparyphus, n. sp.? Williston, Canad. Ent., XVII, 7, p. 126.

After writing the description of this insect, Doctor Williston must have concluded that it is a good species, for the specimen now appears in the collection of the University of Kansas under the above name in his own writing. I take pleasure in giving the name for publication.

Chrysochroma albipes Town.

Chrysonotus albipes, n. sp., Townsend MS.

Male: Front green, finely scrobiculate, with yellow pile, that on vertex rather long, tubercle above antennæ and ocelli light yellow; face yellow, with yellow pile and slightly under than front, mouth-parts yellow, cheeks very narrow, black,

bearing white pile, occiput black with whitish pruinose; antennæ yellow, short hairs of first and second joints black, arista black, slightly enlarged at base where it is also sparsely plumose; thorax green, with mesonotum and scutellum finely scrobiculate and covered with yellow pile, very narrow white line along dorsopleural suture, post-alar callosity with a yellowish cast, pleura with violaceous reflections and white pile, halteres yellow; abdomen subshining bronze, wholly covered with yellow pile; coxæ yellow, base of middle and posterior ones shiny green, femora light yellow, middle and posterior ones brownish green near apex, tibiæ and tarsi, except last joint which is brown, light yellow, thickly covered with short white pile; wings hyaline with a smoky tinge, except extreme base, stigma light greenish yellow. Length, 9.7 mm.

One specimen; Guito, Mexico.

This specimen I found in the Townsend material, now forming a part of the collection in the University of Kansas. It bore a manuscript label of the above name, and as I have been unable to find a published description of it, I take pleasure in presenting one here.

ACROCERIDÆ.

Opsebius pterodontinus O. S., Berl. Ent. Zeit., Bd. XXVII, 1883, Heft II.

Opsebius agelenæ Mel., Ent. News, Vol. XIII, No. 6.

That Mr. Melander overlooked Osten Sacken's species is evident from the fact that he did not include *pterodontinus* in his table.

CONOPIDÆ.

Oncomyia propinqua, n. sp.

Male: Black, with uniform grayish pollen, subshining; face and cheeks yellow, in certain lights silvery, front luteous, black on upper half, with a mixture of black and yellowish pile, occiput black on upper half, antennæ rufous, upper border and distal end of third joint black, arista brown, second joint scarcely longer than the third, proboscis and a spot on clypeus black; mesonotum, scutellum and pleuræ uniformly grayish pollinose and yellowish pilose, halteres yellow; abdomen with first and second segments and venter of a reddish cast, remainder uniformly cinerous pollinose and yellowish pilose; legs wholly blackish, except base of tibæ, which are yellowish, pulvilli and

claws, except apex, yellow; wings slightly infuscated, yellowish towards base, veins brown. Length, 4.5 mm.

Habitat?

This species stands between *O. abbreviata* Loew. and *O. baroni* Will., agreeing with the former in coloration and with the latter in size and length of the antennal joints It differs from the latter in the femora, being wholly blackish.

Zodion.—*Table to the species.*

1. Scutellum triangular, thorax with opaque and black spots...*pictulum* Will.
   Scutellum oval 2
2. Very small species, rarely 4 mm. long..... 3
   Larger species..... 5
3. First posterior cell closed..... *parvus*, n. sp.
   First posterior cell open..... 4
4. Sixth and seventh abdominal segments reddish..... *nanellum* Loew.
   Sixth and seventh abdominal segments in general color black, *pygmæum* Will.
5. First posterior cell closed 6
   First posterior cell open..... 9
6. Palpi quite long, clavate..... *palpalis* Robt.
   Palpi not long and clavate 7
7. Petiole at distal end of first posterior cell longer than the small cross-vein ..... *scapularis*, n. sp.
   Petiole shorter than the cross-vein..... 8
8. Abdomen largely rufous..... *bicolor*, n. sp.
   Abdomen largely black ..... *abitus*, n. sp.
9. Posterior part of abdomen golden yellow..... *auricaudatum* Will.
   Abdomen not so colored..... 10
10. Thorax with a pair of median pollinose stripes; abdomen with oblique pollinose spots on at least the third segment..... *obliquefasciata* Macq.
    Thorax pollinose, with at least two slender black stripes; abdomen more uniformly pollinose..... *fulvifrons* Say.

Zodion obliquefasciata Macq.

Myopa obliquefasciata Macq., Dipt. Exot. 1er Suppl., 141, 1.
Zodion splendens Jaen., Neue Exot. Dipt., 405, Mexico.
Zodion leucostoma Will., Trans. Conn. Acad., VI, p. 380.

Specimens received through exchange from Prof. C. W. Johnson, and bearing the name *Z. obliquefasciata* Macq., led me to believe that the above synonymy is correct.

Zodion abitus, n. sp.

Female: Black, grayish pollinose; face and cheeks yellow, in some light silvery, front black on upper part, fulvous near antennæ, occiput black on upper half, proboscis black, palpi small,

yellow, antennæ rufous, with black hairs, arista black at base; mesonotum black, gray pollinose, with two short, indistinct black lines, pleuræ and scutellum black, gray pollinose, the former devoid of pile except on sterno-pleuræ; abdomen black, subshining, sides of second, middle and sides of third and following segments gray pollinose; legs, except knees, uniformly reddish yellow; wings slightly infuscate, lighter near base, veins brown, first posterior cell closed and petiolate, petiole shorter than the small cross-vein. Length, 4.5 mm.

Two specimens; Kansas and Massachusetts.

This species is close to *Z. fulvifrons* Say, but differs from it in size, the subshining abdomen, and closed posterior cell.

Zodion scapularis, n. sp.

Male: Black, grayish pollinose, pile black; face and cheeks yellow, latter one-half the height of eye, front narrow, fulvous, with a black line on each side above, antennæ red, first joint, distal end of third, and arista, black, occiput, proboscis with a short palpi, black; thorax black, grayish pollinose, inner half of humeri shining black, scutellum and pleuræ black, the latter, except the sternopleuræ, devoid of pile, halteres yellow; second and third segments of abdomen red, subshining, pollinose on sides, remaining segments black, covered with gray pollen, pile black; legs, except knees and pulvilli, black; wings tinged with brown, veins black, first posterior cell closed, petiolate, with the petiole longer than the small cross-vein. Length, 5 mm.

One specimen; Arizona. Prof. F. H. Snow.

Near *Z. palpalis* Robt., but differs in the short palpi, shining spot on humeri, and wholly pollinose fourth abdominal segment.

Zodion parvis, n. sp.

Male: Black; face and cheeks yellow, front fulvous, black at vertex and narrow along sides, antennæ red, hairs and arista black, occiput and proboscis, with the short palpi, black; mesonotum, scutellum, pleuræ subshining, pollen gray, most prominent on humeri and below base of wings, halteres yellow, pile black; abdomen black, subshining, the gray pollen seen more distinctly on the sides, pile black; legs, except basal half of tibiæ, metatarsi, and pulvilli, black; wings, except base,

tinged with brown, veins dark brown, first posterior cell closed and petiolate, the petiole almost as long as the posterior cross-vein. Length, 3.5 mm.

Two specimens; Arizona. Prof. F. H. Snow.

Zodion bicolor, n. sp.

Male: Black, gray pollinose; face and cheeks yellowish white, front fulvous, darker on upper half, antennæ red, hairs and arista black, occiput largely, and proboscis with the small palpi wholly, black; thorax thickly gray pollinose, pile black, halteres yellow; first segment of abdomen black, remaining segments red, pile black; legs reddish, with front and middle femora on top and hind ones near apex, all tibiæ and tarsi near apices black; wings, except base, tinged with brown, first posterior cell closed and petiolate, petiole shorter than the small cross-vein. Length, 5 mm.

Two specimens; Douglas county, Kansas. Prof. F. H. Snow.

Myopa.— *Table to the species.*

1.	Cheeks below very distinctly fringed with pile; wings with spots........	2
	Cheeks not fringed with pile below..	3
2.	Face with black spots..................................	*pictipennis* Will.
	Face without black spots; pile of abdomen long..............	*pilosa* Will.
3.	Abdomen chiefly black..	4
	Abdomen red or reddish..	5
4.	Pile of abdomen light yellow...........................	*vesiculosa* Say.
	Pile of abdomen black..................................	*plebeia* Will.
5.	First posterior cell closed..................................	*clausa* Loew.
	First posterior cell open..	6
6.	Mesonotum, except humeri and sides, black.................	*tectura*, n sp.
	Mesonotum with three black spots............	*clausa* var. *aperta* Roeder.

The above is a continuation of Doctor Williston's table to receive the new species.

Myopa tectura, n. sp.

Male: Rufous, opaque; face and cheeks yellow, front concolorous, with ocellar spot black, antennæ red, shorter than in *aperta*, hairs black, upper half of occiput reddish, proboscis and palpi brown; thorax red, mesonotum, except sides and humeri, and metanotum black, latter subshining, halteres yellow, knobs reddish; abdomen opaque, rufous throughout, pile black; coxæ rufous, black at apices, femora and tibiæ opaque red,

knees yellowish, tarsi yellowish, last joint black; wings, except base, light brown, first posterior cell open. Length, 9 mm.

Habitat?

PIPUNCULIDÆ.

Pipunculus nigricornis, n. sp.

Male: Head black, occiput, front above the antennæ, and face silvery pollinose, mouth-parts yellowish brown, antennæ black, third joint short acuminate, arista black, swollen at base; thorax black, mesonotum brownish pollinose, pleuræ and metanotum silvery pollinose, scutellum subopaque, halteres black with base brown; abdomen black, subopaque, first segment with narrow posterior border, second, third and fourth segments with an interrupted posterior band which widens laterally, and the fifth segment with a broad posterior band, white pollinose, hypopygium black, with cleft to the right of median line; coxæ black, silvery pollinose, femora, except both ends, tibiæ narrowly in the middle, and the last joint of the tarsi, black, other parts yellow, all femora grayish pollinose except the hind ones on inner side; wings hyaline, stigma fuscous, small cross-vein slightly before the tip of the auxiliary vein and at the junction of the basal and middle thirds of the discal cell. Length, 4.2 mm.; wings, 5 mm.

One specimen. Collected by the writer near Atherton, Mo., May 19, 1901.

Pipunculus fuscitarsis, n. sp.

Male: Head black, occiput, front near antennæ and face silvery pollinose, mouth-parts brown, antennæ black, third joint short acuminate, in certain lights with a whitish reflection, base of arista swollen; thorax black, mesonotum brown pollinose, humeri inclined to yellow, pleuræ and metanotum silvery pollinose, scutellum concolorous, halteres dark brown; abdomen black, first segment with a narrow posterior band white pollinose, also a few black bristly hairs on each side, the remainder of abdomen uniformly brownish pollinose, hypopygium subshining black, cleft to right of median line; legs largely black. uniformly gray pollinose except hind femora on inner side, knees and tips of tibiæ yellow, tarsi brownish with last joint black; wings, except base, slightly tinged with fuscous, stigma dark brown, small cross-vein opposite tip of auxiliary

vein and slightly beyond the junction of the basal and middle thirds of the discal cell. Length, 4.5 mm.; wing, 5.2 mm.

One specimen; New Mexico, August. Collected by Prof. F. H. Snow.

SAPROMYZIDÆ.

Pachycerina dolorosa Will.

Pachycerina dolorosa, n. sp., Williston MS.

Female: Reddish yellow, shining vertical spot, under side of the third joint of the antennæ and the abdomen black; wings brown; head as in *P. verticalis*, the ocellar spot larger, the third joint of the antennæ longer, and distinctly black on the under side; the palpi narrower, eyes a little smaller, the cheeks broader, and the face somewhat more receding; mesonotum with a median black or deep brown stripe; femora dark brown at the base; front femora, otherwise, brownish; front tibiæ and tarsi, except the immediate base of the former, black, middle tarsi brownish; wings brown, deeply so along the costa; penultimate section of the fourth vein nearly as long as the ultimate section. Length, 5 mm.

Abdomen shining black.

Five specimens; Colorado. Comstock. No. 241, Morrison.

(The above description is Doctor Williston's.)

OSCINIDÆ.

Chlorops.—*Table to the species.*

1.	Mesonotum black, at most with sides yellow	2
	Mesonotum not so colored	11
2.	Legs largely black	3
	Legs largely yellow	5
3.	Front with a median sulcus	*fossulata* Loew.
	Front without a median sulcus	4
4.	Palpi black	*pullipes* Coq.
	Palpi yellow	*bilineata*, n. sp.
5.	Mesonotum grayish pollinose	6
	Mesonotum not grayish pollinose	7
6.	Third antennal joint linear	*nigricans* Loew.
	Third antennal joint ovate	*pulchripes* Loew.
7.	Hind tibiæ brown or black in the middle	8
	Hind tibiæ reddish yellow or yellow	9
8.	Scutellum piceous	*procera* Loew.
	Scutellum yellow	*scabra* Coq.
9.	Palpi black	*abdominalis* Coq.
	Palpi yellow	10

10. Third longitudinal vein curving forward....................*confluens* Loew.
Third longitudinal vein straight..............................*grata* Loew.

11. Antennæ, except sometimes the arista, wholly black.................. 12
Antennæ not wholly black 14

12. Legs largely black..............................*appropinqua*, n. sp.
Legs largely yellow.. 13

13. Frontal triangle wholly black..........................*melanocera* Loew.
Frontal triangle with two oval spots......................*liturata*, n. sp.

14. Palpi largely black.. 15
Palpi yellow... 20

15. Arista black..*crocota* Loew.
Arista largely whitish... 16

16. Face marked with black 17
Face not marked with black 18

17. Face with two black lines...................................*eucera* Loew.
Face with four black lines ....*sanguinolenta* Loew.

18. Clypeus black on sides.................................*maculosa* Loew.
Clypeus yellow 19

19. Third antennal joint wholly black ....*pubescens* Loew.
Third antennal joint not wholly black......................*palpalis*, n. sp.

20. Mesonotum without distinct markings................................ 21
Mesonotum with distinct markings................................... 22

21. Pleuræ immaculate ....*unicolor* Loew.
Pleuræ spotted ....*microcera* Loew.

22. Mesonotum with three black vittæ 23
Mesonotum with five black vittæ.................................... 27
Mesonotum largely red, with two grayish lines.............*alternata* Loew.

23. Third vein curving forward 24
Third vein straight or nearly so 26

24. Third antennal joint wholly black.......................*gundlachi* Loew.
Third antennal joint black at apex 25

25. Arista black..*parva*, n. sp.
Arista largely white......................................*versicolor* Loew.

26. Front with a longitudinal sulcus...........................*mellea* Loew.
Front without such sulcus ....*assimilis* Macq.

27. Arista white, at most base yellow.................................. 28
Arista not white, at least base brown or black 30

28. Third antennal joint wholly black.................................. 29
Third antennal joint with apex black.....................*rubicunda*, n. sp.

29. Clypeus black ....*aristalis* Coq.
Clypeus yellow ....*trivittata* Will.

30. Humeri usually with black spots.................................... 31
Humeri not with black spots.. 38

31. Face much produced below................................*producta* Loew.
Face not produced below.. 32

32. Clypeus wholly black or brownish black............................. 33
Clypeus black only on the sides.................................... 34

33. Posterior tibiæ wholly yellow.......................... *obscuricornis* Loew.
Posterior tibiæ brownish annulate....................... *sahlbergii* Loew.
34. Abdomen largely yellow .... *quinquepunctata* Loew.
Abdomen largely black 35
35. Second and third veins curved forward..................... *recurva*, n. sp.
Second and third veins straight... 36
36. The yellow of abdomen confined to bases of segments.......... *ingrata* Will.
The yellow of abdomen confined to apices and lateral margins of segments, 37
37. Third antennal joint wholly black .... *halteralis*, n. sp.
Third antennal joint not wholly black..................... *variceps* Loew.
38. Third antennal joint wholly black.. 39
Third antennal joint not wholly black 41
39. Terminal portion of the arista white......... 40
Terminal portion of arista not white...................... *sulphurea* Loew.
40. Abdomen largely black.................................. *graminea* Coq.
Abdomen largely yellow............................ *albifascies*, n. sp.
41. Pleuræ spotted.. *rubida* Coq.
Pleuræ immaculate.................................. *cinerapennis*, n. sp.

In the above table no attempt has been made towards a subdivision of the genus, it being intended merely for an easy disposition of the known species of *Chlorops* in its widest sense.

Chlorops appropinqua, n. sp.

Head yellow, occiput on upper half, frontal triangle, antennæ, except arista, which is brownish, clypeus wholly, and palpi, black, third antennal joint rounded, cheeks at least as wide as one-half the eye height, the frontal triangle smooth, except on the sides, and reaches the anterior edge of the front; thorax yellow, mesonotum with three broad black stripes reaching its entire length, pleuræ with three black spots, scutellum yellow, blackish on sides at base, halteres yellow; abdomen black, narrow lateral margins, apex and venter yellow; legs black, the knees, middle and hind coxæ, middle tibiæ almost wholly, posterior tibiæ at extreme tip, and base of middle and hind tarsi yellow; wings hyaline, second and third veins almost straight, hind cross-vein slightly more than its length from the small. Length, 3.5 mm.

Eleven specimens from Hamilton and Morton counties, Kansas, collected by Dr. F. H. Snow; two from Garden City, Kan., collected by H. W. Menke; two from Lusk, Wyo., collected by Messrs. W. A. Snow and Hugo Kahl, and two from Colorado.

At first I took this to be that form of *Chlorops pallipes* Coq.,

which has two yellow stripes on the mesonotum, but, after more careful study and comparison with specimens of *pullipes*, I recognized in it a new species. The cheeks are much broader than in *pullipes*, and the coloration of the legs and abdomen different.

Chlorops cinerapennis, n. sp.

Head yellow, middle of occiput, frontal triangle narrowly, the rounded third antennal joint, except inner side of base, and base of arista, black, face, cheeks and mouth-parts light yellow; thorax yellow, mesonotum with the usual three broad black stripes plus the two narrow ones above base of wing, pile yellowish brown, dense but extremely short, causing a pollinose appearance on the black parts, pleuræ and scutellum immaculate, halteres yellowish white; abdomen fuscous, posterior margins of segments and spot on anterior angles of second segment darker, venter yellow, pile black; legs yellow, with the tip of the tarsi fuscous; wings intense grayish hyaline, second and third veins about straight, hind cross-vein twice its length from the small. Length, 3.5 mm.

Two specimens; Riley county, Kansas. Marlatt.

Chlorops bilineata, n. sp.

Head yellow, occiput, except upper and lower angles, frontal triangle, antennæ, with base of arista, and clypeus, black, face on sides with two narrow brown lines, third joint of antennæ rounded, arista with terminal portion white; mesonotum black, lateral margins yellow, humeri each with a black spot, pleuræ reddish yellow with four black spots, scutellum brownish, halteres yellow; coxæ yellow, femora and tibiæ, except each end, black, tarsi fuscous towards tip; abdomen black, narrow lateral margins and posterior border of last segment yellow; wings hyaline, second and third veins curving forward, hind cross-vein slightly lesst han its length from the small. Length, 4 mm.

One specimen; North Park, Colo. Collected by Dr. F. H. Snow.

Chlorops liturata, n. sp.

Head yellow, occiput in the middle and narrowly on sides, frontal triangle, except two oval yellow spots, antennæ except arista, clypeus on sides, and palpi, black; third joint of an-

tennae rounded, arista yellow at base, whitish at tip, frontal triangle does not reach anterior border of front, the latter bearing a few black hairs; mesonotum with the usual three broad, black stripes and the two narrow ones above base of wings, pile black, humeri each with a black dot, pleuræ yellow, marked with six black spots, scutellum yellow, blackish on sides at base, halteres yellow; legs yellow, a spot on base of front coxæ, one on top of each femora, the posterior tibiæ near middle, front tarsi wholly, and middle and hind tarsi except base, brownish black; abdomen brownish black, base of first segment, lateral margins and tip of last segment yellow, venter brown; wings hyaline, second and third veins straight, hind cross-vein more than its length from the small. Length, 5 mm.

Four specimens; Lusk, Wyo. Collected by W. A. Snow and Hugo Kahl.

Chlorops recurva, n. sp.

Head yellow, occiput in the middle, and narrowly in the middle of the sides, the short frontal triangle, the rounded third antennal joint, with base of arista, and cypleus, black; first two antennal joints and terminal portion of arista brownish yellow, palpi yellow; mesonotum yellow, with the usual three broad and two narrow black stripes, humeri each with a black dot, another black dot behind the humeri, and on the extreme lateral margin is a brown line running from the humeri to the base of the wing, pleuræ yellow, with six black spots, scutellum narrowly yellow in the middle, dark brown on the sides, halteres whitish yellow; legs reddish yellow throughout, tips of tarsi fuscous; abdomen brownish black, apex and venter yellowish; wings hyaline, second and third veins curved forward, cross-veins approximated. Length, 3.4 mm.

One specimen; Lusk, Wyo. Collected by W. A. Snow.

Chlorops halteralis, n. sp.

Head yellow, occiput except sides, the narrow, elongate, frontal triangle, the rounded third antennal joint with the arista, and clypeus on the sides, black, face whitish yellow, palpi yellow; thorax yellow, five dorsal vittæ, two humeral dots, four spots on pleuræ, and metanotum, shining black, halteres whitish; legs yellow, tips of tarsi fuscous; abdomen shining brownish black, lateral margins, apices of segments

and venter yellow; wings hyaline, second and third veins about straight, hind cross-vein one and a half times its length from the small. Length, 2.5 mm.

One specimen; Arizona. Collected by Dr. F. H. Snow, August, 1902.

Chlorops palpalis, n. sp.

Head reddish yellow, occiput with two narrow lines above, frontal triangle with ocellar dot, and a spot in each angle, the rounded third antennal joint, except base, and palpi, black, arista whitish with base yellow, face and cheeks light yellow; mesonotum reddish yellow, shining, with the usual three broad black stripes and two narrow lateral ones, humeri without black dots, pleuræ without markings, scutellum reddish yellow, halteres whitish; legs, except the fuscous tips of the tarsi, yellow; abdomen fuscous, posterior margins of segments and venter yellowish; wings hyaline, second and third veins straight, hind cross-vein twice its length from the small. Length, 3.2 mm.

Two specimens; Atherton, Mo. Collected by the writer during May and July.

Chlorops albifascies, n. sp.

Head yellow, center of occiput above, frontal triangle, rounded third antennal joint, with base of arista, black, frontal triangle with a shallow longitudinal sulcus, first two joints of antennæ dark brown, distal portion of arista whitish, face whitish, mouth-parts yellow; mesonotum yellow, marked with five opaque black vittæ, humeri without dots, pleuræ and scutellum yellow, immaculate, halteres whitish; legs yellow, tips of tarsi black; abdomen largely obscure yellow, sutures and spot in anterior angle of second segment black, venter yellow; wings hyaline, second and third veins straight, hind cross-vein over twice its length from the small. Length, 3.5 mm.

Seven specimens; Atherton, Mo. Collected by the writer during May and June.

Chlorops parva, n. sp.

Head yellow, occiput except upper and lower parts of sides, the small frontal triangle, distal portion of the rounded third antennal joint, the short pubescent arista, and the clypeus, black, palpi yellow; mesonotum yellow, with three opaque

black vittæ, humeri each with a black dot, also a spot below each, pleuræ with three black spots, scutellum and halteres yellow; abdomen light fuscous, blackish towards base, lateral margins yellow; legs yellow, tarsi fuscous; wings hyaline, second vein almost straight, the third curving forward, cross-veins approximated. Length, 1.8 mm.

One specimen; Douglas county, Kansas.

Chlorops rubicunda, n. sp.

Head yellow, face and cheeks reddish yellow, occiput, except sides, frontal triangle largely, tip of third antennal joint and clypeus black, third antennal joint slightly longer than wide, base of arista yellow, terminal portion white, short pubescent, palpi yellow, frontal triangle with a shallow median sulcus; mesonotum yellow, sometimes with a reddish tinge, marked with five opaque black vittæ, humeri each with a black dot, pleuræ reddish yellow, marked with four black spots, scutellum yellow, halteres whitish; abdomen brownish black, lateral margins and venter largely black; legs yellow, femora on upper side, tibiæ near middle, and tip of tarsi, fuscous; wings hyaline, second vein straight, third curving forward, hind cross-vein about twice its length from the small. Length, 4 mm.

Three specimens; Lusk, Wyo. Collected by W. A. Snow and Hugo Kahl.

II. AFRICAN SPECIES.

CONOPIDÆ.

Conops fumipennis, n. sp.

Male: Front reddish, face velvety yellow, in certain lights of a silvery-yellow reflection, cheeks and occiput reddish, antennæ reddish throughout, first and third joints subequal, second about one and one-half times as long as either, proboscis reddish, black at tip; thorax rufous, the three dorsal vittæ confluent, sprinkled with whitish pollen; pleuræ rufous with silvery-white dusted strip, attenuated above; scutel rufous, metanotum black below, whitish pollinose above; halteres light yellow, brown at base; first segment of abdomen black with a narrow red hind border which is sprinkled with a yellowish-white dust; second, third and fourth segments red, blackish above, with a yellow-dusted posterior border which in some cases extends forwards

on the sides; fifth segment red with a narrow anterior border black, the remainder of the dorsum and of the following segment covered with yellow pollen; legs red, front coxæ black at base, tibiæ with a silvery reflection exteriorly, front, middle and posterior tarsi, except base, black, pulvilli and tarsal claws, except tips, light yellow; wings wholly obscure brown, darker along the veins, slightly tinged with yellow at base and near tip of auxiliary vein. Length of body, 14 mm.; wing, 10.5 mm.

Seven specimens; Salisbury, South Africa. Frank L. Snow.

Conops bellus, n. sp.

Male: Front, occiput and cheeks reddish, face velvety yellow, in certain lights silvery yellow; proboscis reddish, black at tip; antennæ reddish, third joint brownish underneath, first and third joints equal, second at least twice as long as either; thorax and scutellum red, the three black dorsal vittæ coalesced, pollen whitish, most distinct in certain lights on the humeri and pleuræ; metanotum black below, red above, sprinkled with whitish pollen above and on the sides, halteres yellow, brownish at base; abdomen in large part red, black on base of segments, which, on some segments, is continued backwards as a median line or spot; on posterior margin of first segment whitish dust, that of second, third and fourth segments yellow; fifth and sixth segments nearly wholly covered with yellow pollen; legs red, front coxæ blackish at base, tibiæ with silvery reflections exteriorly; front, middle and hind tarsi at tips black; wings with costa land subcostal cells yellowish brown, marginal, submarginal, entire base and anterior half of apex of first posterior cell dark brown, first basal cell, except a small spot near apex, bases of discal and third posterior cell and the whole of the anal cell light brown. Length of body, 13 mm.; wing, 9.5 mm.

One specimen; Salisbury, South Africa. Frank L. Snow.

Conops semifumosus, n. sp.

Male and female: Front, occiput and cheeks brown; face velvety yellow, in certain lights silvery; proboscis rufous, black at tip; antennæ rufous, third joint inclining to yellow, first and third joints of equal length, second twice as long as either; thorax rufous, the three black dorsal vittæ coalesced; pleuræ

rufous, black just above the coxæ, with a narrow, silvery dusted line near wing; scutellum rufous; metanotum almost entirely black, silvery and pollinose above, which extends upon the sides; halteres yellow; abdomen red, more or less black on dorsum of first, third, fourth and fifth segments, posterior borders of first five segments and the sixth almost wholly covered with yellow pollen; legs reddish, tibiæ with silvery reflections exteriorly, front and middle tarsi dark brown, posterior ones lighter; wings with costal, subcostal, marginal, submarginal cells, and basal half and anterior part of distal half of first posterior cell brown, which also encroaches upon the proximal portion of basal cells, remainder of wing hyaline. Length of body, 12.5 mm.; wing, 9 mm.

Three specimens; Salisbury, South Africa. Frank L. Snow.

DIOPSIDÆ.

Diopsis affinis, n. sp.

Head light red, ocellar tubercle and an arcuate line on front black, spinate on each side of oral margin; eyestalks red, black at apex, median bristle small, black, apical spine strong, black; antennæ testaceous, arista brown, subdorsal; eyes black, large; thorax black, dorsum shining, humeri, anterior, lateral and posterior margins grayish pollinose; pleuræ black, grayish pollinose; scutellum shining black, pollinose on margin; spines shining testaceous, black at tip; halteres yellowish white; abdomen shining testaceous, venter obscure yellowish, pile sparse; legs pale testaceous; anterior coxæ light gray pollinose, front femora thickened, front tibiæ and tarsi brown, four hind femora armed with spines at distal end; wings hyaline, tinged with brown, veins dark brown. Length, body, 7 mm.; wing, 6 mm.; eyestalk, 2.5 mm.

One specimen; Salisbury, South Africa. Frank L. Snow.

Diopsis pollinosus, n. sp.

Head obscure testaceous, two obscure cross-bands on front, lateral spines of oral margin small; eyestalks reddish brown, expanded ends black; antennæ red, arista brown, subdorsal; thorax and scutellum black, wholly gray pollinose; spines of scutellum brown, yellowish at tip; halteres pale yellow; abdomen black, first segment gray pollinose, second and third segments shining, with lateral gray pollinose spots, remaining seg-

ments wholly gray pollinose; legs reddish brown, anterior femora thickened, anterior tibiæ dark brown, anterior metatarsi testaceous, other joints brown; middle and posterior tarsi pale brown; wings brownish hyaline, a < shaped gray hyaline band with its apex at the tip of anal cell, a transverse gray hyaline band crossing the first posterior cell at about its middle. Length of body, 5.5 mm.; wing, 4.3 mm.; eyestalks, 1.5 mm.

One specimen; Salisbury, South Africa. Frank L. Snow.

Teleopsis nitidus, n. sp.

Head shining brown, with sparse white hairs; eyestalks reddish brown, short, extremely shining black, median bristle long, black, and situated upon a rather enlarged black tubercle; antennæ light reddish, arista dark; thorax and scutellum shining black; spines of scutellum pale yellow, shining black in the middle; abdomen shining black throughout, clavate, with sparse white pile; legs light brown, anterior femora slightly incrassate, other femora toward apex, tibiæ near base and last two joints of tarsi dark brown; wings hyaline, with three transverse brown bands, first one narrowed anteriorly and connected with the second near its middle; second and third connected by a band just the width of the first posterior cell; the hyaline apex of wing faintly tinged with brown. Length of body, 3.5 mm.; wing, 2.2 mm.; eyestalk, 8 mm.

One specimen; Salisbury, South Africa. Frank L. Snow.

SCIOMYZIDÆ.

Sepedon scapularis, n. sp.

Front broader than one of the eyes, excavated, rufous; face yellow, covered with pale yellow pollen; cheeks shining yellow anteriorly, covered with pale yellow pollen posteriorly; occiput shining, rufous, with an obscure narrow transverse line just above the middle of eye height, another one, arcuate, just above the lower corner of eye; mouth-parts mainly rufous, palpi clavate, pale yellow, rufous at tip; first joint of antennæ rufous, second black, rufous toward base, furnished with black hair, third joint lanceolate, black, arista pubescent, white on distal two-thirds, brown at base; thorax black, subshining, scutellum concolorous, three black bristles on lateral margins of thorax, two of them near base of wing; humeri, thorax above front coxæ and a small spot below base of wing testace-

ous, pleuræ black; first segment of abdomen black, remaining testaceous; coxæ and base of femora testaceous, outer end of latter rufous, hind ones with black ring at base and short dark spines beneath, tip of anterior and posterior tibiæ, anterior and posterior tarsi and last two joints of middle tarsi black; wings hyaline, tinged with fuscous, more so towards apex. Length of body, 7 mm.; wing, 7 mm.

Two specimens; Salisbury, South Africa. Frank L. Snow.

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CONTENTS:

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KANSAS UNIVERSITY SCIENCE BULLETIN.

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AN ECOLOGICAL CATALOGUE OF THE CRAYFISHES BELONGING TO THE GENUS CAMBARUS.

BY J. ARTHUR HARRIS.

With plates I to V.

INTRODUCTION.

DURING the last few years, much attention has been given to biological or ecological considerations in both botany and zoology, as one may easily convince himself by turning the pages of but a few volumes of current botanical or zoological journals. Concerning the importance of this work opinions are, naturally, greatly at variance. Some, in their enthusiasm, forget that ecological observations are valuable only as they contribute to our knowledge of the causes of the form and structure of the plant or animal body and the nature of its reactions to the conditions under which it exists, and fully merit the criticism of some of the older and more conservative morphologists and systematists, that ecology is a very superficial study. Others assign to the newer phase of scientific investigation its more nearly correct value, in regarding it as a very essential aid to an understanding of form and relationship. One can hardly deny the truth of the suggestion which may be offered by some, that ecologists are "making a mess" of the work they are trying to do, but those who have something of an acquaintance with the earlier morphological or taxonomic literature may at least suspect that the "ecological mess" is not the first one which has been made since men began recording their observations on plants and animals. There is in ecological work, and here possibly more than in almost any other field, an unfortunate tendency to build large and beautiful theories

on the smallest amount of data, and this is certainly deserving of criticism, but at the present time there need be offered no excuse for the publication or correlation of data of an ecological character, and little doubt that eventually, if they be carefully made, the observations will be of importance in the decision of really fundamental questions.

The paper embodied in the following pages has been sent to the press only after considerable hesitation, and since in some respects it is essentially different from the usual type of scientific publication, a few words of explanation, though not of apology, seem to be quite in place.

In the fall of 1898, at the suggestion of Prof. C. E. McClung, of the department of zoology, University of Kansas, I began studying the crayfishes to be found in the region around the University, and such material as I could obtain from other parts of the state. Being much interested in vegetable ecology at the time, I naturally was interested in the ecological phase of the new work. The most of my own observations have been published, but over two years ago I began to feel the importance of bringing together for a comparative study all that is known of the habits of the North American forms, and work was immediately begun by going through the literature and making abstracts of all parts of a biological nature. More recently I decided that the distribution of all the species should be presented in the same paper. The data are very meager and unsatisfactory, and I fully appreciate the fact that the necessary field-work has been only begun, and if it seemed possible for me to do further field-work I would not publish at the present time; but there seems little immediate hope of my being able to carry on the work in the way I would desire, and so it is deemed advisable to present the material brought together in as convenient a form as possible, in the hope that it may be of use to others more favorably situated for field observations, and perhaps serve as a nucleus or a suggestion for a much more extensive and valuable piece of biological work on this or some other genus.

In explanation of the purpose of portions of the paper, it seems desirable to mention in the briefest way some of the work which has been done on distribution in its more limited sense.

In 1850 Agassiz[1] noticed that there is a difference between

1. Agassiz, L. Lake Superior. Boston, 1850.

the species of fishes occurring in the upper and lower part of the courses of a stream, and in 1854[2] he pointed out more fully the importance of such investigations.

In 1868 Cope[3] studied the distribution of the fishes of the Alleghany region and arrived at several very important conclusions. Since that time various papers containing data and conclusions on the distribution of the fresh-water fishes have appeared,[4] and Jordan has presented[5] in detail the facts as they are known up to the present time.

More recently work of much interest has been done in plant and animal ecology. Cowles has published[6] a paper of great botanical interest in which he emphasizes the importance of the genetic and dynamic in physiographic ecology. The relation of biology to physiography has been emphasized in papers by Woodworth,[7] Hays and Campbell,[8] Simpson,[9] and Adams.[10] The results are well summarized by Adams.

The conclusions and suggestions in these papers, as well as of some others which have appeared, cannot be given in detail here, but those who are acquainted with them will understand my point of view in the compilation of the data dealing with the distribution by river systems. A single genus of a moderately large number of species of diverse habitat and wide distribution obviously offers advantageous material for a study of ecological adaptations—more favorable material for comparison than species taken from different genera.

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2. Agassiz, L. Am. Jour. Sci. and Arts, 2d ser., vol. XVII, p. 25. 1854. I have seen only quotations from this paper.

3. Cope, E. D. On the Distribution of the Fresh-water Fishes in the Alleghany Region of Southwestern Virginia. Jour. Acad. Nat. Sci. Phila., n. s., vol. VI, pp. 207-247. 1868.

4. Jordan, D. S. On the Distribution of Fresh-water Fishes. Am. Nat., vol. XI, pp. 607-613, 1877.

Jordan, D. S. On the Distribution of the Fishes of the Alleghany Region of South Carolina, Georgia, and Tennessee, with Descriptions of New or Little-known Species. Bull. U. S. Nat. Mus., vol. XII, pp. 7-95, 1878.

Forbes, S. A. A Catalogue of the Native Fishes of Illinois. Ann. Rep. Ill. Fish Com. 1884, pp. 60-89, 1884.

Jordan, D. S., and Gilbert, C. H. List of Fishes Collected in Arkansas, Indian Territory, and Texas, in September, 1884, with Notes and Descriptions. Proc. U. S. Nat. Mus 1886, pp. 1-25, 1887.

5. Jordan, D. S. Science Sketches, new ed., Chicago, 1896.

6. Cowles, H. C. The Physiographic Ecology of Chicago and Vicinity: A Study of the Origin, Development and Classification of Plant Societies. Bot. Gaz., vol. XXXI, pp. 73-108, 145-182, 1901.

7. Woodworth, J. B. The Relation between Base-leveling and Organic Evolution. Amer. Geologist, vol. XIV, pp. 209-235, 1894.

8. Hays, C. W., and Campbell, M. R. The Relation of Biology to Physiography. Science, n. s., vol. XII, pp. 131-133.

9. Simpson, C. T. On the Evidence of the Unionidæ Regarding the Former Courses of the Tennessee and Other Southern Rivers. Science, n. s., vol. XII, pp. 133-136.

10. Adams ('01).

The habits of any species are necessarily directly dependent, in a great measure at least, upon the physical conditions under which it lives, and a knowledge of habits and habitat are necessarily so intimately connected that from a biological or ecological standpoint they cannot be separated. As our knowledge of the ecological relations of the species of a genus becomes more complete, we will be prepared to consider the structural peculiarities or adaptations of the different species, and so to have a much clearer idea of the origin and significance of specific characters.

That, in many groups, the time for these considerations, except in the more specialized cases, is not yet come, is perfectly evident. Furthermore, I am not at all unacquainted with a quite general revulsion to the too nearly universal tendency to see in every animal or plant structure some advantageous ecological adaptation, and in case direct observations do not furnish proof of such adaptation, either to explain its absence on the ground of insufficient knowledge of the living organism, or, as is too often the case, manufacture a pleasing theory in explanation. With many of the expressions of this feeling I am thoroughly in sympathy, but I cannot feel that the proper way of disposing of the matter is to characterize ecology as superficial or cheap and to ignore it entirely.

Systematic work, as the term is too generally interpreted—the description of species, the preparation of manuals with artificial keys, and "a list of species collected"—is certainly indispensable, but cannot be regarded as other than preliminary. In its better sense—the determination of the origin and relationship of species and groups, great and small—systematic work has an immense and vastly important field for the future. For this work the description and monographing of species and the preparation of faunal lists[11] is important and must precede other work, but it cannot be considered as the ultimate end of scientific investigation by any means. Much of the ecological work which is being done must be regarded in the same way—as preliminary work, the data of which will aid in the so-

11. Mr. Adams ('01) has expressed himself as follows: "The time is past when faunal lists should be the aim of faunal studies. The study must not only be comparative, but *genetic*, and much stress must be laid on the study of the habitat—not in a static, rigid sense, but as a fluctuating or periodical medium. The bearing of faunal studies upon the problem of differentiation and the origin of species is very close, and in our search for the factors we must not lose the perspective, and overlook those factors which are fundamental and work through long periods of time."

lution of greater problems. A knowledge of the habits or distribution of the species of a genus is not in itself of the greatest importance, but, if it enable us to determine something of the nature of structural adaptations to environment, it is contributing to the data for the solution of some of the problems of fundamental importance. The recognition of the fact that certain work is preliminary in nature, and that it is merely to furnish data for work of greater importance which would be incomplete or impossible without it, is not the slightest justification for the neglect of any field. Ecological questions are not the only ones, but a thorough knowledge of the ecological relations of the different species of a genus, in connection with a study of structural differences and a consideration of physiographic changes affecting distribution, will certainly contribute very greatly to a definite knowledge of some phases of evolution.

For several reasons *Cambarus* offers a particularly inviting field for ecological work. A more thorough knowledge of the habits of the animals may, possibly, contribute much to a full understanding of the very remarkable sexual dimorphism occurring in the adult males. Individual variation is very great and puzzling—so much so that Professor Stimpson is said to have remarked that either there is only one species of crayfish in eastern North America or each mud puddle has its own. The genus has certainly undergone a remarkable differentiation into species. There are now recognized nearly eighty species and varieties from the range of distribution in North America, as compared with about thirteen species of *Astacus*, the other genus of the crayfishes of the northern hemisphere, from Europe, Asia, and America. As Faxon has pointed out, this difference is not to be attributed to more thorough exploration of the American territory. The chances for addition of species by further exploration seem to be greatly in favor of *Cambarus* rather than *Astacus*. Doctor Faxon ('90) has said: "I have reason to believe that oftentimes in this genus mere varieties, coming into contact in a given locality, are perpetuated by breeding true, when, by extending our geographical range, every intermediate condition connecting the two forms will be found still surviving. Nowhere do we seem to come so near to seeing the process of evolution of species going on under our very eyes as in this genus *Cambarus*. It seems to me that the only criteria of a

species must be the amount and character of the variation, and the absence of intermediate forms, not in one locality alone, but over the whole area of distribution."

That the conditions of environment under which the different species of *Cambarus* are found are very diverse is apparent to any one who is acquainted in a general way with the physical features of different regions in which crayfish are known to occur. A study of these conditions and the adaptation of the animals to them may be expected to yield some interesting results.

While thoroughly convinced of the importance of an ecological study of the crayfishes, I recognize perfectly that for the majority of species of the genus it is as yet impossible to draw any conclusions at all as to the character of habitat or any adaptation to it, but we do know quite definitely in a few cases in what type of locality a given species may be found, and in some cases structural adaptations are very marked, and it is my hope that the arrangement of all the data so far secured in a convenient form for ecological work will shorten the time till our knowledge of these questions may be much more comprehensive than it is at present.

In the following pages is given, in as condensed a form as has been considered advisable, abstracts of all that has appeared on the habits of the different species, so far as it was regarded as worthy of notice, and a list of all the known localities of the species of *Cambarus*, with the drainage basin to which they belong. This has been compiled and presented as necessary data for a consideration of the ecological relations of any species, or group of species. While I feel that with our present knowledge of the subject generalizations are of little value, and have sought to indulge very temperately in conclusions, I have in some cases expressed my opinion as to the significance of the facts observed. The main purpose of the paper, however, is the compiling and recording in an easily accessible form of such biological data as have been secured up to the present time, in the hope that they may be of use to those who have better opportunities than I for further work along this line. Of some of the imperfections of the paper as it is here presented I am as fully aware as the most of those who may see it, but the

pressure of other work, as well as some other considerations, makes me feel that publication at the present time is desirable.

A few words of explanation of the arrangement of material may be in place here. The purpose of the paper being the presentation of data so far secured in easily accessible form, the arrangement is a purely artificial one. For convenience of reference the species are arranged alphabetically. Under each species is given a catalogue of all the localities from which it has been reported. In a catalogue of fresh-water animals prepared for ecological work, it is evidently better to have the material reported from streams rather than from cities, and I have given, so far as I have been able to determine from maps, the stream to which each lot of material probably belongs, or which drains the territory from which it was taken. This may seem to some an addition of little importance, since so far as the range of distribution of a species in a broad way is not affected by its occurrence in Nelson's creek or Big river, so long as it is known that it was taken near Pineville, in the eastern part of the state, but those who are acquainted with the aims of some phases of ecological work will fully appreciate the desirability of obtaining all bits of data, even though small and unsatisfactory. For the mere purpose of determining the drainage systems in which each species occurs, it has been necessary to go over the localities carefully, and it has been thought best to record the decision in each case. As a matter of convenience, the county has also been added when possible, all supplied material being enclosed in brackets. The states are arranged alphabetically and numbered, and under them the localities are numbered, so that cross-reference is made convenient. (*C. diogenes* 15.1 referring to the first locality for *C. diogenes* given under Kansas.)

Following the catalogue of localities is given a review of the material of an ecological nature which has appeared on the species under consideration. By means of summaries and tables at the end, it is the intention to bring together and compare points of similarity and dissimilarity in the different species. That the purely artificial arrangement is open to criticism I am fully aware, but it seems to me the best in a paper the object of which is merely the arrangement of data in convenient form

for future work. The natural arrangement of the species in the genus is as follows:

GROUP I.

C. blandingii, Ga., Md., Miss., N. J., N. Y., N. C., S. C., Tex., Va.
blandingii acutus, Ala., Ark., Ill., Ind., Ind. Ter., Iowa, La., Miss., Mo., N. C., Ohio, S. C., Tenn., Tex., Wis.
fallax, Fla.
hayi, Miss.
clarkii, Ala., Fla., La., Miss., Ohio, Tex.
troglodytes, Ga., Ill., S. C.
lecontei, Ala., Ga.
angustatus, Ga.
pubescens, Ga.
spiculifer, Ga.
versutus, Ala., Fla.
alleni, Fla.
evermanni, Ala.
barbatus, Ala., Ga., Miss., S. C.
wiegmanni, Mex.
pellucidus, Ind., Ky. (caves).
pellucidus testii, Ind. (caves).
acherontis, Fla. (caves).

GROUP II.

C. simulans, Kan., N. M., Tex.
mexicanus, Mex.
advena, S. Ga.
gracilis, Ill., Ind., Iowa, Kan., Mo., Ohio, Wis.
carinatus, Mex.
cubensis, Cuba.
hagenianus, S. C.
? *clypeatus*, S. Miss.

GROUP III.

C. bartonii, Can., D. C., Ga., Ind., Ky., Me., Md., Mass., Mo., N. J., N. Y., N. C., Ohio, Pa., R. I., S. C., Tenn., Vt., Va., W. Va.
bartonii robustus, Can., Ill., Md., N. Y., Pa., Tenn., Va.
bartonii longirostris, Ala., Tenn., W. Va.
longulus, N. C., Tenn., Va., W. Va.
carolinus, I. T., N. C., Pa., Tenn., Va., W. Va.

uhleri, Md. ("eastern shore").
latimanus, Ala., Ga., Miss., S. C., Tenn.
acuminatus, N. C., S. C.
extraneus, Ala., Ga., Tenn.
extràneus girardianus, Ala., Tenn.
jordani, N. Ga.
argillicola, Can., Ill., Ind., La., Mich., Miss., N. C., Ohio, Tex.
diogenes, Ark., Colo., D. C., Ill., Ind,, Iowa, Kan., Ky., Md., Mich., Minn., Miss., Mo., N. Y., N. C., Ohio, Pa., Tenn., Va., Wis., Wyo.
diogenes ludovicianus, La.
cornutus, Ky.
hamulatus, Tenn. (Nickajack cave).
setosus, S. W. Mo. (caves).

GROUP IV.

C. lancifer, Ark., Miss.
affinis, Lake Superior, Lake Erie, D. C., Md., N. J., N. Y., Pa., Va.
indianensis, S. Ind.
sloanii, S. Ind., Ky.
propinquus, Can., Ill., Ind., Iowa, Mich., N. Y., Ohio, Pa., Wis.
obscurus, N. Y., Pa.
propinquus sanbornii, Ky., Ohio.
neglectus, Ark., Iowa, Kan., Mo., Tex.
harrisonii, Mo.
virilis, Can., Ala., Ark., Ill., Ind., I. T., Iowa, Kan., Mich., Minn., Mo., Neb., N. Y., N. Dak., Tenn., Tex., Wis., Wyo.
immunis, Ala., Ill., Ind., Iowa, Kan., Mich., Minn., Mo., Neb., N. Y., Ohio, Wis., Wyo., Mex.
immunis spinirostris, Ind., Kan., Tenn.
hylas, Mo.
pilosus, Kan.
nais, Kan.
mississippiensis, Miss.
palmeri, Ark., Tenn.
palmeri longimanus, I. T., Tex.

longidigitus, Ark.
difficilis, I. T., Ark.
meekii, Ark.
erichsonianus, Ala., Tenn.
alabamensis, N. Ala.
compressus, N. Ala.
medius, Mo.
rusticus, Ala., Ark., Ill., Ind., Iowa, Kan., Ky., Mich., Mo., Ohio, Pa., Tenn., Tex., Wis.
spinosus, N. Ala., Ga., N. C., S. C., Tenn.
putnami, Ind., Ky., Tenn.
forceps, N. Ala., Va. Tenn.
digueti, Mex.

GROUP V.

C. montezumæ, Mex.
montezumæ dugesii, Mex.
montezumæ areolatus, Mex.
montezumæ occidentalis, Mex.
shufeldtii, La.
chapalanus, Mex.

PARASITISM IN CAMBARUS.

According to Moore ('93), various writers have discussed the Discodrilidæ parasitic on the European *Astacus fluviatalis*, and Whitman has considered those living on the crayfishes of Japan. He finds that our American forms carry about a "heterogeneous burden of leech-like parasites (or messmates?)," *C. bartonii* being affected by at least four easily distinguishable forms, while other and different forms have been found on *C. affinis*, and on a *Cambarus* sp. inhabiting the larger mountain streams of North Carolina. He presents descriptions of the species and some notes on their place of occurrence. The species and notes of interest in this place are the following:

Branchiobdella illuminata Moore, sp. nov. Very common, being found in the branchial chambers, which it never appears to leave except at the time of molt, during the life of the crayfish in nearly one-half the larger individuals of *C. bartonii* examined. Cocoons found throughout the year attached to the branchial filaments, especially the inner ones. Philadelphia, Pa., and Watauga county, North Carolina.

B. pulcherrima Moore, sp. nov. Cocoons usually attached to

broader surfaces of body, as sides of carapace, inner faces of anterior abdominal epimera, and external face of tail fin. Adults found attached almost anywhere on exterior of crayfish, but more especially on the tergal surfaces. On *C. bartonii*, Watauga county, North Carolina.

B. instabilis Moore, sp. nov. Cocoons usually attached to palmar surface of propodite of great chelæ. Animals largely restricted in distribution to the same segments of the limb; usually to be found in numbers clustered at the base of the pinchers, to which position the form of the body particularly adapts them; frequently wandering to other parts of the same limb, or even to the following pairs of ambulatory limbs. Watauga county, North Carolina, and Delaware county, Pennsylvania.

B. philadelphica Leidy. According to Leidy ('52), this species is found frequently in numbers from one to several dozen upon any part of the exterior of the body of *A. bartonii*, but more especially upon the interior surface and the branchiæ, but Moore ('93) never found it inhabiting the branchial chamber, but principally the sternal surface of the entire body, among the bases of the appendages. Cocoons attached to abdominal sternites, but more frequently to the setæ of pleopods; found principally in summer, but not entirely absent at any season. Philadelphia, Pa., and Watauga county, North Carolina.

Bouvier ('97) states that of the twenty specimens of *C. digueti* received four were attacked by *Temnocephala* and two carried a large number of *Branchiobdella*.

THE COLORS OF CAMBARUS.

Owing largely to the necessary condition of our museum material, very little is known of the colors of our crayfishes. In the systematic literature there are a few references to this characteristic in the descriptions of the species, but with these we are not concerned here.

Kent ('01) has recently published observations, for the most part on *C. immunis*, with some work on *C. propinquus*, *C. bartonii*, and *C. diogenes*, in which he concludes that in nearly all cases the color of the animals closely resembles that of the environment, being blue in color in a pond where the bottom was of blue clay, black where there was a muddy, black bot-

tom, and of different colors in other places. An exception to this was found in those of a red color. These were found entirely in the shallow water in small streams, and the writer concludes from this, and from experiments in which crayfishes in black, blue and green colors were changed to brown and red when kept in an aquarium exposed to light,[12] that the red color is due to the influence of the light. Specimens of different colors taken from different localities and kept in a zinc tub showed, after several months, in some cases a change of color to that of their surroundings. In April and May the coloration of the young crayfish was studied and the conclusion reached that the red color, due to large, scattered chromatophores of the young crayfish, changed to blue or black or underwent no change, according as the adults were blue, black, or red.

C. diogenes, he says, furnishes an excellent example of color change. The individuals of this species which, accord'ng to him, may be found in any of the smaller streams, in the early spring show various colors, but later in the year are nearly all red. They burrow during the winter, and come out in the spring much the color of the soil, and these colors are gradually turned to red in the open sunlight.

He concludes, then, that the colors of crayfish are due to two causes, the influence of environment and the effect of sunlight,[13] and that in all cases these colors serve as protection against enemies.

The question of coloration is by no means a simple one, and without opportunity for an examination of the literature, or more detailed observations than I have been able to make, I do not care to offer explanations, but may call attention to one or two facts which have come to my notice. The colors of a species are certainly not always the same when found in different localities, but I have never been willing to state that the difference should be regarded as a protective adaptation, although this might be the case. Mr. Kent states that the change in

12. Of this he says: "This is a difficult experiment to carry out. Crayfish which live in deeper water become strongly photopathic and can endure only very weak light. It was necessary at first to place the aquarium with the crayfishes in diffused light and to allow them to become accustomed by degrees to the changed conditions." It is unfortunate that he does not give in more detail the injurious effect of the light upon the animals. In nature some of the burrowing forms are exposed to light of considerable intensity upon emerging from their burrows in the spring. So far as has been recorded, the cave forms are not affected by exposure to light. Compare Putnam's observations on *C. pellucidus*.

13. He mentions in the first part of the paper the effect of sunlight in changing the color of pigment when removed from the animal, but, with the exception of heat, does not consider other factors which might produce this change.

color requires some weeks, or possibly months, of time, and that, since many species of crayfish are migratory, especially those living in running water, the color of those seen in small streams may not be at all like their environment, and that the best results may be obtained from a study of those in the small ponds, where migration cannot occur. Until our knowledge of the habits of this genus is much fuller than it is now, one should be careful in stating that many species are migratory in their habits, unless the terms are carefully limited.

The point in regard to the colors of *C. diogenes* is especially interesting. It will be noticed that the habits of the species as observed by Mr. Kent are quite different from those usually attributed to it, for it seems usually to occur in the open water for but a very limited part of the year. My observations on *C. diogenes* are not extensive, but in *C. gracilis* the females which are found in the open ponds for some time in the spring are of the same olive-green color during the entire period. In the very large series of material I have collected in open water I have never found an exception, nor did the two or three specimens I have taken from burrows late in the summer show any differences, but the four or five males, all first-form—the adult second-form not being known— were all of a beautiful salmon-red color, and in all cases I have every reason to believe they had just come from burrows, a point in which I am certain in two cases. The young of both sexes up to an inch and more in length show a coloration somewhat similar to that of the adult female. It is interesting to notice that, according to Faxon, *C. carolinus* (*C. dubius* Fax.), another of the burrowing forms, is known to the Indians in the Territory as "red crayfish," and that, according to Williamson ('01), it has, in Allegheny county, Pennsylvania, a very different color.

In this place the colors of the cave species need not be considered, since this is touched upon under the individual species. It would be interesting to examine the young in reference to the development of color, as has been done in the case of some of the cave-inhabiting fishes. For those who have the opportunity, be it for experimental or field observation, the colors of these animals certainly offer an interesting problem.

THE DIMORPHISM OF CAMBARUS.

The consideration of the very remarkable condition of a sexual dimorphism in the adult males of *Cambarus* is within the scope of the present paper in so far as it is connected with the breeding habits of the animals. The taxonomic importance of the existence of the two forms was pointed out by Doctor Hagen ('70) and has been since confirmed for every species of which a large series of males has been examined. Doctor Faxon ('84*b*) announced the true nature of the dimorphism as an alternation of forms in the individuals. Harris ('01*b* and '01*c*) confirmed Faxon's observations on a much more extensive series of material, finding that there are apparently exceptions to the rule of the alternation of the two forms in the adults, and made a cytological study of testicular material, showing that when the season at which material is secured is taken into consideration no marked difference in the essential reproductive organs of the two forms is observable. In *C. immunis*, and perhaps in *C. virilis* as well, the proportion of first-form males gradually increases in late summer and autumn, there being, so far as he could determine, no definite time for exuviation. In the spring the animals appeared in the open water early in March and all males taken up to April 15 were first-form, but in a very short time afterward nearly all the males had assumed the second-form condition. His study of a series of testes led him to the conclusion that so far as the presence of sexual elements is concerned the second-form is as capable of copulation as the first-form, and that in the adult the second-form condition probably represents the period in which the regeneration of the sexual elements for the most part takes place. He also points out the parallel between the alternation of forms in *Cambarus* as secured by spring and fall exuviation and the spring and autumn exuviation in the male of *Astacus* as described by European observers.

Hagen and Faxon considered that the second form is probably sterile, and the rudimentary condition of the external male organs, the pleopods and hooks on the legs (for a discussion of the function of these, see the section on conjugation) would certainly suggest this view, but the work on the microscopic structure of the testis leaves no doubt as to the presence of the spermatozoa in the same quantity, and apparently in the same

condition, as in the first-form. In a letter of October 29, 1901, Prof. W. P. Hay, of Washington, whose work on the crayfishes is well known, and whom I have to thank for various courtesies, says: "I think you are entirely correct in your observations, and have settled some points beyond doubt. I have long been of the opinion that males of the second-form are not sterile, for I have often seen them copulating, and, after the act was completed, have found masses of sperm on the sternites of the female. Of course, the spermatozoa might be inert, but such a condition would, so far as I know, be without parallel."

This observation of Professor Hay's I regard as important, considering the highly different physical characteristics of the two forms, their constant occurrence in all the well-known species of the genus, and the absence, so far as we now know, of such in the other genera of this family, unless it be in *Cambaroides*.

THE CONJUGATION OF CAMBARUS.

Mr. E. A. Andrews first published observations on this subject. In the American Naturalist he ('95) describes the process in detail, giving two figures from photographs. In the Zoologischer Anzeiger he gives (95*b*) about the same observations in condensed form. The following is quoted from his paper in the Zoologischer Anzeiger:

"Some observations on the breeding habits of *Cambarus affinis* show that there are important differences between the American crayfish, *Cambarus*, and the European crayfish, *Astacus*, and that certain structures hitherto known only as specific and generic characters are necessary accessory reproductive organs.

"1. When kept in confinement *Cambarus affinis* conjugated in November and in February, March, and April.

"2. The process lasts several hours.

"3. The male exhibits great skill and persistency, and is visibly excited throughout the process, while the female is from the first passive and inert and shows scarcely any evidence of excitement.

"4. The sperm is introduced into the cavity in the annulus, which thus serves as a sperm receptacle, as in the lobster,

Homarus americanus, as described by Professor Bumpus. (Journal of Morphology, V, 1891.)

"5. The well-known hook on the ischiopodite of the third walking leg of the male is used in the process of conjugation to firmly attach the male to the female. The tip of the hook depresses the membrane between the coxopodite and basiopodite of the fourth walking leg of the female, and the hook catches firmly against a stiff ridge on the basiopodite.

"6. The sperm is conveyed down the groove of the stylet or first pleopod of the male from the penis-like everted end of the vas deferens into the cavity of the annulus of the female. The annulus becomes filled and a plug of sperm and protective secretion projects from the orifice after conjugation.

"7. At a definite stage in the process, the male always passes either the right or left fifth, or last, walking leg across under the thorax so that it projects horizontally from the other side. The limb then holds the first and second pleopods, the intromittent apparatus, depressed at an angle of more than forty-five degrees from the ventral surface of the male, and this insures their entrance into the annulus when the male moves forward over the female.

"8. During the process the ventral sides of the two animals are closely applied to one another and the abdomen of the male partly encloses the abdomen of the female. The latter lies on the back or partly on one side and is firmly held by the large chelæ of the male which grasps all the chelate appendages of the female.

"9. There is no wide distribution of sperm as has been described for *Astacus;* it is all placed in the annulus. The oviducts of the female are not concerned in the process of conjugation.

"In the one case in which eggs were laid in captivity, the nervous system of the female was very irritable for several days. During the time, by assiduous labor with both of the fifth walking legs, she carefully removed all foreign matter from the ventral surface of the abdomen and from the pleopods.

"The sperm plug remained in the annulus for two days after the eggs were laid and then disappeared. It was probably removed by the female. The process was, however, abnormal and the eggs did not develop."

About a dozen cases were observed in the laboratory by Mr. Andrews. The entire process lasted from two to ten hours and might be repeated by either animal with some other. The two were so firmly united that it was perfectly easy to transfer them from one dish of water to another to examine the more minute details of the process with a hand lens. By throwing the animals into actively boiling water for a few moments he found it possible to fix them in their natural position, in which they may then be preserved indefinitely.

Shufeldt ('98) gives a figure of a pair of conjugating *C. affinis*. The figure much resembles those given by Andrews. Through the courtesy of Doctor Shufeldt, the figure is reproduced in plate I.

LIST OF SPECIES.

Cambarus acherontis LONNBERG.

8. Florida.

1. Lake Brantley, Orange county. (Lonnberg, '94.)
2. Gum Cave, Citrus county. (F., '98.)

This species was described by Doctor Lonnberg ('94) from Orange county, Florida. In digging a well, a subterranean rivulet was struck at a depth of about forty-two feet, after passing through sand and clay, and finally five feet of phosphate rock, bones and teeth of sharks, and a thin layer of hard limestone. At first the crayfish were quite numerous, but later, when Doctor Lonnberg visited the place, only the two types could be found.

Doctor Lonnberg considers that the age of the subterranean rivulet in which the crayfishes were found is probably Post-Pliocene or still younger. He considers the other caves in which blind *Cambari* have been found comparatively much older, and so thinks it is at least possible that *C. pellucidus* and *C. hamulatus* have a much greater phylogenetic age than *C. acherontis*.

The subterranean water-system of Florida must be, Doctor Lonnberg thinks, quite extensive. The ancestors of this species—probably *C. clarkii*—may have forced their way into the rivulet from its exterior mouth, or have more probably fallen in when one of the numerous sink-holes of the region was formed.

Cambarus acuminatus Fax.

32. North Carolina.

1. James river [Johns R.], Morganton [Burke county]. (F., '90.)
2. Swannanoa river, Black mountain [Buncombe county]. (F., '90.)
3. Neuse river, Raleigh [Wake county]. (F., '90.)
4. Reedy fork, Cape Fear river, Greenborough [Guilford county]. (F., '90.)
5. French Broad river [Madison or Buncombe county]. (F., '85.)
6. [Trib. Catawba R.], Old Fort, McDowell county. (F., '85.)

39. South Carolina.

1. Saluda river, west of Greenville [Greenville county]. (F., '85.)

According to Mr. John Tull, who is acquainted with the territory, the Johns river at Morgantown is a cold, clear, rocky, mountain stream, narrow and deep, swiftly flowing in most places. The Swannanoa river (32.2) is about the same in character, being possibly a little more rapid flowing. The Catawba river at Old Fort (32.6) is very similar to the Johns river at Morganton, although the two streams at Morganton, where they are about three miles apart, are very different in character, the Catawba being broader, shallower, more muddy, and not so cold.

The localities known, with two exceptions, indicate that this is an inhabitant of mountain streams. Its occurrence in the head waters of streams flowing into the Atlantic ocean and in the head waters of a tributary of the Tennessee river in the same mountains is interesting. Faxon states that the material from the French Broad river and McDowell county differs from the other, and may prove to be a distinct species.

Cambarus advena LeC.

9. Georgia.

1. "Habitat in Georgia inferiore. Hyeme vitam degit subterranean. Aestate in fossis invenitur." (LeConte, '56.)

Cambarus affinis Say.

?Lake Erie. (F., '85, and '90.)
Lake Superior. (F., '85.)

7. District of Columbia.

1. [Potomac R.], Washington. (F., '85.)

19. Maryland.

1. [Potomac R.], Montgomery county. (F., '85.)
2. Potomac river, Charles county. (F., '85.)
3. [Potomac R.], Williamsport, Washington county. (F., '85.)
4. [Potomac R.], Cumberland, Alleghany county. (F., '85.)
5. [Chesapeake bay], Anne Arundel county. (F., '85.)
6. [Patapsco R.], Gaynns Falls, Druid Hill, etc., Baltimore county. (F., '85.)
7. [Chesapeake bay], Cecil county. (F., '85.)

29. New Jersey.

1. [Trib. Delaware R., or Raritan R.], Schooley's Mountain, Morris county. (F., '85.)
2. [Delaware R.], Camden county. (F., '85.)
3. [Delaware R.], Trenton [Mercer county]. (F., '85.)
4. [Delaware R.], Burlington [Burlington county]. (F., '85.)
5. [Navesink R.], Red Bank, Monmouth county. (F. '85.)

31. New York.

1. [Niagara R.], Niagara [Niagara county]. (F., '85.)

37. Pennsylvania.

1. [Schuylkill R.?] [——— county]. (F., '85.)
2. [Trib. Delaware R.], Reading [Berks county]. (F., '85.)
3. [Delaware R.], Philadelphia [Philadelphia county]. (F., '85.)
4. [Trib. Susquehanna R.], Carlisle [Cumberland county]. (F., '85.)
5. [Susquehanna R.], Bainbridge [York county]. (F., '85.)
6. Susquehanna river. (F., '85.)
7. [Delaware R.], Bristol [Bucks county]. (F., '85.)
8. Brandywine creek [Chester county]. (F., '85.)

45. Virginia.

1. Potomac river, Gunston, Fairfax county. (F., '85.)
2. Shenandoah river, Waynesborough [Waynesboro], [Augusta county]. (F., 90.)
3. Blackwater river, Zuni [Isle of Wight]. (F., '90.)

Abbott ('73) characterizes this as "a deep water [as compared with *C. acutus*], stone-hunting form." In the neighborhood of Trenton, N. J., he found it usually resting under flat stones well out from the banks of the stream, where the water was of considerable depth, and also in fewer numbers on the mud-bottomed portions of the river. He found none among the vegetation, where *C. acutus* was abundant. There was nothing to indicate that it is a burrowing species.

Smith ('74) takes his material from Abbott ('73).

Faxon ('85) states that since Abbott's paper ('73) appeared Doctor Abbott and he have taken *C. affinis* in great numbers from shallow ditches in the Delaware meadows, near Trenton, N. J.,

in company with *C. blandingii*, and that, "According to Mr. P. R. Uhler, *C. affinis* is the common form in the warmer parts of the rivers and creeks of Maryland, underneath the stones. In his collection are specimens from Montgomery county labeled as found in stagnant pools, and specimens from Alleghany county, four miles below Cumberland, were taken from 'holes in the bottom and sides of a canal.' "

See, also, parasitism and Faxon ('85), under *C. pellucidus*.

Cambarus alabamensis Fax.

1. Alabama.

1. Second creek, Waterloo, Lauderdale county. (F., '85.)

Cambarus alleni Fax.

8. Florida.

1. St. Johns river, Hawkinsville, Orange county. (F., '85.)
2. [Gulf drainage], Hernando county. (F., '85.)
3. Caloosahatchee river [Lee or Desoto county]. (F., '90.)
4. A little creek, Hillsborough county. (Lonnberg, '94.)
5. Small lakes around Apopka and several other places, Orange county. (Lonnberg, '94.)
6. Ditches and small ponds, Arcadia, Desoto county. (Lonnberg, '94.)

Lonnberg ('94) expresses the opinion that this is a form widely distributed in south Florida, and that *C. alleni* and *C. fallax*, having never been found outside of the state, have probably become differentiated as species there, and that their existence as such can, then, not extend farther back than to the Pliocene.

From the catalogue it will be seen that the distribution is quite extensive, and that they are found in the territory drained by both the Gulf of Mexico and the Atlantic.

Lonnberg ('95) says of *C. alleni* and *C. fallax* in Florida: "They lived in creeks, small lakes, and ponds, very often hiding in the rich vegetation there, or under logs, boards, and so on. Sometimes I found them digging holes on the shore, at low water, and these holes often went down to such a depth that the water came up into them."

C. alleni he took in October in a small creek in Hillsborough county, all the males being second-form. In Orange county, he found this species in small lakes around Apopka "and several other places." At Acadia, Desoto county, he took it in ditches and small ponds.

Cambarus angustatus LeC.

9. Georgia.

1. Le Conte ('56) says: "Habitat in Georgia inferiore, in aquæ puræ rivulos qui inter colleculos arenosus (sand-hills) currunt."

Cambarus argillicola Fax.

Canada.

1. [Lake Ontario], Toronto, P. O. (F., '85.)

11. Illinois.

1. Lowlands bordering on Wabash river, York, Clark county. (F., '90.)

12. Indiana.

1. [White R.], Irvington, Marion county. (Hay, '96.)
2. [White R.], Bloomington, Monroe county. (Hay, '96.)
3. [Trib. White R.], Wheatland, Knox county. (Hay, '96.)
4. [Trib. Ohio R.], New Albany [Floyd county]. (Hay, '96.)

17. Louisiana.

?1. [Mississippi R.], New Orleans [Orleans county]. (F., '85.)

21. Michigan.

1. [Trib. Lake St. Clair], Detroit [Wayne county]. (F., '85.)
2. [Trib. of Shiawassee R.], East Saginaw [Saginaw county]. (F., '85.)

23. Mississippi.

1. Bay St. Louis, Hancock county. (F., '98.)

32. North Carolina.

?1. [Neuse R.], Kinston, Lenoir county. (F., '85.)

34. Ohio.

1. Kelley's island, Lake Erie. (F., '90.)
2. [Trib. Lake Erie], Oberlin [Lorain county]. (Hay, '96)

42. Texas.

1. [Guadalupe R.], Victoria [Victoria county]. (F., '98.)
2. [Brazos R.], Brazoria [Brazoria county]. (F., '98.)

Faxon ('84 and '85) says: "The types of this species were dug out of burrows in solid blue clay in Detroit, Mich., by Mr. H. G. Hubbard, in August, 1873. The burrows were three to five feet deep. At the bottom of each burrow was a pocket in a layer of loose gravel and clay, holding water. Just above the water-line an enlargement in the burrow formed a shelf on which the animal rested."

Faxon ('90), in reporting this species from the lowlands bordering on the Wabash river, Clark county, Illinois, says: "According to the manuscript label accompanying these speci-

mens, they were found in burrows from eighteen inches to two feet in depth, containing from six inches to one foot of water. At the mouth of these burrows were mud chimneys five inches high. The soil was blue clay mixed with sand and gravel."

According to Hay ('96), *C. argillicola*, like its near relative *C. diogenes*, is a burrower and builds mud chimneys over its burrows. He took females with young as early as April 2.

Cambarus barbatus LeC.[14]

1. Alabama.

1. Escambia river, at Flomaton, above Pensacola [Escambia county]. (F., '90.)

9. Georgia.

1. Georgia. (F., '85.)

23. Mississippi.

?1. Eastern Mississippi. (F., '85.)

39. South Carolina.

?1. [Atlantic O.], Charleston. (F., '85.)

Cambarus bartonii Fabr.

Lake Superior. (F., '85.)

Canada.

?1. [St. Lawrence R.], Montreal, P. Q. (F., '85.)
2. [St. John R.], St. John, N. B. (F., '85.)
3. St. John river, just above Grand Falls, N. B. (F., '90.)
4. Abundant in valley of St. John, N. B. (Ganong, '98.)
5. Restigouche river, N. B. (Ganong, '98.)
6. Upsalquitch river, N. B. (Ganong, '98.)
7. Micomichi river, N. B. (Ganong, '98.)

7. District of Columbia.

1. Rock creek, Georgetown. (F., '85.)
2. [Potomac R.], above Washington. (F., '85.)

9. Georgia.

?1. Hagen states that he has seen specimens from Georgia. (F., '85.)

12. Indiana.

1. [White R.], Fall creek, Indianapolis, and Irvington, Marion county. (Hay, '96.)
2. [White R. or east fork of White R.], Bloomington, Clear creek, and May's cave, Monroe county. (Hay, '96.)
3. [Ohio R.], New Albany [Floyd county]. (Hay, '96.)
4. [East fork of White R.], Down's cave, and Connelly's cave, Lawrence county. (Hay, '96.)
5. [East fork of White R.], cave near Paoli, Orange county. (Hay, '96.)

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14. *C. barbatus* was proposed by Faxon ('90) to replace *C. penicillatus* LeC., a preoccupied name.

16. Kentucky.

1. [Clinch R.], Cumberland Gap, Josh Bell county. (F., '85.)
2. Smoky creek, Carter county. (F. '85.)
3. Kentucky river, Little Hickman, Jessamine county. (F., '85.)
4. [——— R.], Hickman's Landing [——— county]. (F. '85.)
5. Bear creek, Grayson springs, Grayson county. (F., '85.)
6. [Green R.], Mammoth cave, Edmonson county. (F., '85.)
7. [Cumberland R.], Albany, Clinton county. (F., '98.)

18. Maine.

1. Head of Kennebec river, outlet of Moosehead lake [Somerset county]. (F., '90.)
2. [Kennebec R.], Madison, Somerset county. (F., '85.)
3. [Trib. St. John R.], Hamilton and Maysville, Aroostook county. (F., '85.)

?4. Moosehead lake and Solon, in the Kennebec valley. (F., '85.)
?5. Lobster pond and Patten, in the Penobscot valley. (F., '85.)
?6. Heron lake and Churchill lake, on Allegash river, a tributary of the St. John. (F., '85.)

19. Maryland.

1. [Potomac R.], Cumberland, Alleghany county. (F., '85.)
2. [Youghiougheny R.], Garret county. (F., '85.)
3. [Trib. Potomac R.], Washington county. (F., '85.)
4. [Trib. Potomac R.], Frederick county. (F., '85.)
5. [Potomac R.], Montgomery county. (F., '85.)
6. [Susquehanna R. or Chesapeake bay], Hartford county. (F., '85.)
7. [Patuxent R.], Howard county. (F., '85.)
8. [Potomac R.], Montgomery county. (F., '85.)

20. Massachusetts.

1. [Blackstone R.], North Grafton, Worcester county. (F., '85.)
2. [Hoosac R.], Williamstown, Berkshire county. (F., '85.)
3. [Hoosac R.], North Adams, Berkshire county. (F., '98.)

?4. Tributary of Housatonic river, Berkshire county. (F., '90.)

24. Missouri.

?1. Osage river. (F., '85.)

29. New Jersey.

1. [Delaware R.], Trenton [Mercer county]. (F., '85.)
2. [Trib. Delaware R. or Raritan R.], Schooley's Mountain [——— county]. (F., '85.)
3. [Passiac R.], Orange [Essex county]. (F., '85.)

31. New York.

1. Lake Champlain [Clinton or Essex county]. (F., '85.)
2. [Trib. St. Lawrence R.], Ellenburg, Clinton county. (F., '85.)
3. [Trib. Hudson R.], Westport and Elizabethtown, Essex county. (F., '85.)
4. Fulton lakes, Hamilton and Herkimer counties. (F., 85.)
5. [La Grasse R.], Canton, St. Lawrence county. (F., '85.)
6. [Delaware R.], Port Jervis and Newburgh, Orange county. (F., '85.)
7. [Hudson R.], Fishkill, Duchess county. (F., '85.)
8. [Delaware R.], Fallsburg, Sullivan county. (F., '85.)
9. [Trib. Susquehanna R.], Sherburne, Chenango county. (F., '85.)
10. [Oneida lake], Cazenovia, Madison county. (F., '85.)

11. [Cayuga lake], Ithaca, Tompkins county. (F., '85.)
12. [Trib. Susquehanna R.], Berkshire, Tioga county. (F., '85.)
13. Genesee river, Rochester, Monroe county. (F., '85.)
14. [Niagara R.], Niagara, Niagara county. (F., '85.)
15. [Lake Erie], Forestville, Chautauqua county. (F., '85.)

32. North Carolina.

1. [Big Pigeon R.], Waynesville, Haywood county. (F., '98.)
2. [Trib. French Broad R.], Roan mountain, from an altitude of 6000 feet [Mitchell county]. (F., '98.)
3. Swannanoa river, Black mountain [Bumcombe county]. (F., '90.)
4. Newman's Fork, Blue Ridge, McDowell county. (F., '85.)
5. [Neuse R.], Kinston [Lenoir county]. (F., '85.)
6. [Trib. Holston R., or south fork New R.], Watauga county. (Moore, '93.)

34. Ohio.

1. [Ohio R.], Marietta [Washington county]. (F., '85.)
2. [Ohio R.], Cincinnati [Hamilton county]. (F., '85.)
3. [Trib. Ohio R.], Yellow Springs [Greene county]. (F., '85.)
4. Scioto river, Columbus [Franklin county]. (F., '85.)
5. [Ohio R.], Warren county. (F., '98.)

37. Pennsylvania.

1. [Trib. Ohio R.], Westmoreland county. (F. '98.)
2. [Juniata R.], Bedford and Pattanville, Bedford county. (F. '85.)
3. [Susquehanna R.], Windham, Bradford county. (F. '85.)
4. [Trib. Susquehanna R.], Hummelstown, Dauphin county. (F., '85.)
5. [Trib. Susquehanna R.], Carlisle, Cumberland county. (F., '85.)
6. [Susquehana R.], Berwick, Columbia county. (F., '85.)
7. Schuylkill river, near Philadelphia [Philadelphia county]. (F., '85.)
8. [Trib. Delaware R.], Chester county. (F., '85.)
9. [Susquehanna R.], Bainbridge, Lancaster county. (F., '85.)
10. [Alleghany R.], McKean county. (F., '85.)
11. [Alleghany R.], Foxburg, Clarion county. (F., '85.)
12. In springs and small brooks, rarely in large streams, Allegheny county. (Williamson, '01.)
13. [Delaware R.], Philadelphia, Montgomery county. (Moore, '93.)
14. [Delaware R.], Delaware county. (Moore, '93.)

38. Rhode Island.

?1. Pawcatuck river, near the border of Connecticut, Westerly [Washington county]. (F. '85.)

39. South Carolina.

?1. [Atlantic O.], Charleston [Charleston county]. (F., '85.)

41. Tennessee.

1. [Tennessee R.], Lineville cave, near Blountsville, Sullivan county. (F., '85.)
2. Doe river, Carter county. (F., '85.)
3. [Tennessee R.], Knoxville, Knox county. (F., '85.)
4. [Clinch R.], Claiborne county. (F., '98.)
5. [Trib. Tennessee R.], Monroe county. (F., '98.)
6. [Trib. Tennessee R.], McMinn county. (F., '98.)

44. Vermont.

1. [Lake Champlain], Burlington, Colchester, and Shelburne, Chittenden county. (F., '85.)

45. Virginia.

1. Peak creek, Pulaski [Pulaski county]. (F., '90.)
2. Shenandoah river, Waynesborough [Augusta county]. (F., '90.)
3. Holston river, Smyth county. (F., '85.)
4. Reed creek, west of Wytheville, Wythe county. (F., '85.)
5. [Trib. James R.], Bath county. (F., '85.)
6. [Trib. Chowan R.], Lunenberg, Lunenberg county. (F., '85.)
7. Tributaries of James river, Rockbridge county. (F., '85.)
8. James river. (F. '85.)
9. Tributaries of Rappahannock river, Stafford county. (F., '85.)
10. [Potomac R.], Alexandria county. (F., '85.)
11. [Blackwater R.], Franklin, Southampton county. (F., '85.)
12. [Shenandoah R.], Clark county. (F., '85.)

47. West Virginia.

1. Branch of Clinch river, northern base of Clinch mountains [—— county]. (F., '85.)
2. [Trib. Kanawha R.], near White Sulphur Springs, Greenbrier county. (F., '85.)
3. [Trib. Ohio R.], Petroleum, Ritchie county. (F., '85.)
4. Patterson's creek [Mineral county]. (F., '85.)
5. Glade creek [Randolph or Tucker county?] (F., '85.)
6. South branch of Potomac river. (F., '85.)
7. [Patterson's creek], Williamsport, Grant county. (F., '85.)

Cambarus bartonii longirostris Fax.

1. Alabama.

1. Will's creek, Pollard, Escambia county. (F., '98.)

41. Tennessee.

1. [Clinch R.], Cumberland Gap [Claiborne county]. (F., '98.)
2. [Holston R.], Blountville [Sullivan county]. (F., '98.)

47. West Virginia.

1. Clinch river. (F., '98.)

Cambarus bartonii robustus Gir

Canada.

1. Humber river and Don river, Toronto, P. O. (F., '85.)
2. Indian creek, Weston, P. O. (F., '85.)

11. Illinois.

1. [Sangamon R.], Decatur, Macon county. (F., '85.)

19. Maryland.

1. [Potomac R.], Montgomery county. (F., '85.)

31. New York.

1. [Lake Erie] Forestville, Chautauqua county. (F., '85.)
2. Genesee river, Rochester, Monroe county. (F., '85.)
3. [Lake Ontario] Sodus, Wayne county. (F., '85.)
4. Tributaries of Racket river, near Tupper's lake, St. Lawrence county. (F., '85.)
5. [St. Lawrence R.], Natural Bridge, Jefferson county. (F., '85.)
6. Fulton lakes, Hamilton and Herkimer counties. (F., '85.)
7. Oneida creek, Peterboro, Madison county. (F., '98.)
8. [Grass R.], Canton, St. Lawrence county. (F., '98.)

37. Pennsylvania.

1. Squaw run which empties into the Alleghany river about a mile and a half above Aspinwall, Allegheny county. (Williamson, '01.)

41. Tennessee.

?1. Doubtfully reported by Faxon ('85).

45. Virginia.

1. [Rappahannock R.], Fredericksburg, Spottsylvania county. (F., '85)
2. [Trib. Kanawha R.], Wytheville, Wythe county. (F., '90.)

Gould ('41) reports this as an inhabitant of mountain streams, etc.

Godman ('42) describes the process of removing a small pebble which he had pushed into the small, irregular hole in the bed of a small brook: "He had thrust his broad, lobster-like claws under the stone, and then drawn them near to his mouth, thus making a kind of shelf; and, as he reached the edge of the hole, he suddenly extended his claws and ejected the encumbrance from the lower side, or down stream."

De Kay ('44) reports it as exceedingly common in the mountain streams of New York and the adjoining states, and as nocturnal in habits, hiding during the day under stones.

Erichson ('46) says: "Sehr haufig in Nordamerika in Bachen."

Abbott ('73) found this the one burrowing species of the region around Trenton, N. J., occurring in deep meadow ditches with muddy banks, in the banks of small streams, and occasionally in the river bank a little below the usual water-level.

According to Faxon ('85), *C. bartonii* is not a preeminently burrowing species like its relative, *C. diogenes*, but prefers the cooler water of the uplands, being found more commonly in clear streams and springs, while the clay bottoms and marshes are inhabited by *C. diogenes*. He reports young specimens

from a spring in Clark county, Virginia, the temperature of which is 67° F. He refers to the association with the cave forms, which has been noticed by various writers. Sloan (Faxon '85) reports this species as found in ponds and still water at New Albany, Ind., *C. sloanii* being the common form in running streams.

Hay ('96) also calls attention to the association with *C. pellucidus*, and says the largest and best-developed specimens he has ever taken came from the limestone caves of southern Indiana. It is to be looked for, however, in almost any spring or stream of clear running water, where it hides under stones or digs short burrows into the banks.

Schufeldt ('96) describes and figures a chimney of *C. bartonii robustus* found near the edge of a small stream in Montgomery county, Maryland, as about nine inches in height, very smooth inside, and with the pellets distinctly individualized outside. Many of the pellets were piled up at the base, and forty-two of them had rolled out beyond it. At a depth of fifteen inches water was reached in the burrow, and it was followed twenty-seven inches further, when it passed between two large stones, rendering further examination impossible.

Williamson ('01) states that in Allegheny county, Pennsylvania, *C. bartonii* is the most common species, being found in springs and smaller brooks, but rarely in larger streams.

Cambarus blandingii Har.

9. Georgia.

1. [Savannah R.], Richmond county. (F., '85.)
2. [Savannah R.], Savannah [Chatham county]. (Lonnberg, '98.)

19. Maryland.

1. [Patapsco R.], Baltimore county. (F., 85.)
2. [Choptank R.], Caroline county. (F., 85.)
3. [Choptank R.], Dorchester county. (F., '85.)
4. [Tribs. Potomac or Patuxent R.], St. Mary's county. (F., '85.)
5. [Chesapeake bay], Somerset county. (F., '85.)
6. [Wicomico or Pocomoke R.], Wicomico county. (F., '85.)
7. In a ditch near Ocean City [Atlantic O.], Worcester county. (F., '85.)

22. Mississippi.

1. [—— R.], Root pond [—— county]. (F., '85.)

29. New Jersey.

1. [Passaic R.], Essex county. (F., '85.)
2. Delaware river and tributaries, near Trenton [Mercer county]. (F., '85.)

31. New York.

1. [——— R.] (F., '85.)

32. North Carolina.

1. [Pamlico R.], Tarboro [Edgecombe county]. (F., '85.)
2. Tributaries of Neuse river, Goldsboro [Wayne county]. (F., '85.)
3. [Neuse R.], Kinston [Lenoir county]. (F., '85.)
4. [Atlantic O.], Beaufort [Carteret county]. (F., '85.)
5. Salmon creek [——— county]. (F., '85.)
6. [Cape Fear R.], Wilmington [New Hanover county]. (F., '85.)
7. Tar river, Rocky Mount [Edgecombe county]. (F., '90.)
8. Neuse river, Raleigh [Wake county]. (F., '90.)

39. South Carolina.

1. [Wateree R.], Camden [Kershaw county]. (F., '85.)
2. Saluda river. (F., '85.)
3. [Congaree R.], Columbia [Richland county]. (F., '85.)

42. Texas.

? [Trinity R.], Dallas [Dallas county]. (F., '85.)

45. Virginia.

1. James river. (F., '85.)
2. [Trib. Chowan R.], Lunenberg [Lunenberg county]. (F., '85.)
3. North river, Lexington [Rockbridge county]. (F., '90.)
4. Dismal swamp, outlet of Lake Drummond, Suffolk [Norfolk county]. (F., '90.)

Cambarus blandingii acutus.

1. Alabama.

1. [Mobile bay], Mobile [Mobile county]. (F., '85.)
2. [Trib. Black Warrior R.], Blount Spring, Blount county. (F., '85.)
3. [Trib. Black Warrior R.], Cullman, Cullman county. (F., '85.)
4. [Tennessee R.], Decatur, Morgan county. [F., '85.)
5. In pond formed by overflow of Tennessee river, Bridgeport, Jackson county. (F., '85.)

2. Arkansas.

1. [White R.], Batesville [Independence county]. (F., '98.)
2. [Trib. Black R.], Mammoth Springs [Fulton county]. (F., '98.)
3. [Washita or Ouachita R.], Camden [Ouachita county]. (F., '85.)

11. Illinois.

1. [Illinois R.], Athens, Menard county. (F., '85.)
2. [Illinois R.], Decatur, Macon county. (F., '85.)
3. [Illinois R.], Pekin, Tazewell county. (F., '85.)
4. [Trib. Illinois R.], Normal, McLean county. (F., '85.)

5. [Mississippi R.], Oquawka, Henderson county. (F., '85.)
6. [Illinois R.], Peoria, Peoria county. (F., '85.)
7. [Illinois R.], Lawn Ridge, Marshall county. (F., '85.)
8. [Lake Michigan], Evanston, Cook county. (F., '85.)
9. [Wabash R.], York, Clark county. (F., '90.)

12. Indiana.

1. [Trib. Wabash R.], Vincennes, Knox county. (Hay, '96.)
2. [Trib. White R. or Wabash R.], Wheatland, Knox county. (Hay, '96.)
3. [Tippecanoe R.?], Turkey lake, Kosciusko county. (Hay, '96.)
4. [Kankakee R.?], Lake Maxinkuckee, Marshall county. (Hay, '96.)
5. Kankakee river, Lake county. (Hay, '96.)
6. [Wabash R.], Terre Haute, Vigo county. (Hay, '96.)

13. Indian Territory.

1. [Trib. Kiamichi R.], Good Land [or Goodland], [Choctaw N.] (F., '98.)
2. [Walnut creek], Kainister [Chickasaw N.] (F., '98.)
3. [Trib. Saines creek], McAlester [Choctaw N.] (F., '98.)

14. Iowa.

1. [Iowa R.], West Liberty [Muscatine county]. (F., '85.)
2. [Mississippi R.], Dubuque [Dubuque county]. (F., '85.)

17. Louisiana.

1. [Mississippi R.], New Orleans [Orleans county]. (F., '85.)
2. Tangipahoa river, Amite City [Tangipahoa county]. (F., '85.)
3. [Tangipahoa R.], Tickfaw [Tangipahoa county]. (F., '85.)

23. Mississippi.

1. Tributary of Tombigbee river, Kemper county. (F., '85.)
2. [Trib. Mississippi R.], near Vicksburg [Warren county]. (F., '85.)

24. Missouri.

1. [Mississippi R.], St. Louis [St. Louis county]. (F., '85.)

32. North Carolina.

1. [Atlantic O.], Beaufort [Carteret county]. (F., '85.)

34. Ohio.

1. Portage river, at Oak Harbor [Ottawa county]. (F., '98.)

39. South Carolina.

1. [Atlantic O.], Charleston [Charleston county]. (F., '85.)

41. Tennessee.

1. [Mississippi R.], Memphis [Shelby county]. (F., '85.)

42. Texas.

1. [Red R.], Arthur [Lamar county]. (F., '98.)
2. [Gulf of Mex.], Corpus Christi [Nueces county]. (F., '98.)

48. Wisconsin.

1. [Lake Michigan], Racine [Racine county]. (F., '85.)
2. [Wisconsin R.], Sauk City [Sauk county]. (F., '85.)

Harlan ('30) says: "Inhabits the Southern states, where it is common in the marshes and rivulets."

Erichson ('46) says: "In den südlichen Staaten von Nordamerika, häufig in Sumpfen und Bächen."

Abbott ('73) found *C. acutus* frequenting running streams in the neighborhood of Trenton, N. J., having masses of vegetation upon which the animal rested, usually near the surface of the water. They were always observed with the head directed down stream. When disturbed, they darted backward down to the roots, apparently of the same plant upon which they were resting; after about ten minutes they would creep up the plant to their former resting-place. Abbott characterizes this as "a plant-loving species."

Smith ('74) reviews Abbott ('73) on this species.

Bundy ('82) says: "It [*C. blandingii acuta* (48.2) *fide* Faxon '85] occurs also in marsh ditches near Sauk City in company with *C. obesus*."

According to Faxon ('85), Mr. P. R. Uhler finds that this species belongs to the lowlands at the mouth of sluggish rivers, or near the ocean in muddy and grassy ditches and drains, and even in salt water, in company with *C. uhleri*. He has specimens from near Ocean City, Worcester county, Maryland [19.7], found in a ditch in holes six to nine inches deep. At Goldsborough, N. C., the same gentleman found it abundant in drains and branches running through cotton-fields, tributaries of the Neuse river [32.2]. The two females from Texas, which agree well with *C. blandingii* (42 ?), are labeled "burrowing crabs.

Lonnberg ('98) says: "The late Capt. C. Eckman, at Savannah, Ga., collected *Cambarus* (*blandingii*) in the hollow trunk of a fallen tree, two English miles from any open water."

See, also, *C. affinis*, *C. uhleri* and Faxon ('85), under *C. pellucidus*.

Cambarus carinatus Fax.

Mexico.

1. [——— R.], Guadalajara. (F., '98.)
2. [——— R.], Ameca, Jalisco. (F., '98.)
3. [——— R.], Hacienda de Villahuato, Michoacan. (F., '98.)

The altitude of Guadalajara is 5200 feet. (F., '98.)

Cambarus carolinus Erichs.[15]

13. Indian Territory.

1. [Trib. Arkansas R.], "Among the Cherokees." (F., 90.)

32. North Carolina.

1. [Tar R.], near Greenville [Pitt county]. (F., 85.)

37. Pennsylvania.

1. [Ohio, Alleghany or Monongahela R.], Shenley Park, Fern Hollow, and from a spring in Moon township, Allegheny county. (Williamson, '01.)

41. Tennessee.

1. [Clinch R.], Cumberland Gap [Claiborne county]. (F., 85.)

45. Virginia.

1. [Trib. Tennessee R.], Pennington's Gap, Lee county. (F., 85.)

47. West Virginia.

1. [Cheat R.], Cranberry Summit, Preston county. (F., '85.)

A species reported from the widely separated localities of northeastern Indian Territory, Allegheny county, Pennsylvania, and the remote Appalachian mountain region of Virginia and West Virginia.

According to Mr. Uhler (Faxon, '84 and '85), this species in the Appalachian region makes mud chimneys, like *C. diogenes*, which it seems to represent in the mountain regions, *C. diogenes* belonging to the lowlands.

Williamson ('01) has studied the habits of *C. dubius* Fax. in Allegheny county, Pennsylvania, where it is represented by a local variety. The chimneys of *C. diogenes* are usually constructed more neatly than those of *C. dubius*, while the burrows of *C. dubius* are usually more intricate In both species the burrows of younger animals are usually small tunnels, ending in a pocket, placed at such a depth that it is filled with water. September 24, one burrow, typical of a large individual of *C. dubius*, contained an adult female and forty-seven young, ranging from three-fourths to one and one-eighth inches in length. The chimney, about three inches high, broad and flattened, was not composed of compact pellets, as is usually the case with *C. diogenes*, and was sealed at the top. The burrow, circular, about one and one-half inches in diameter, and with smooth sides, ran

15. All the localities except North Carolina are for *C. dubius* Fax., the name *C. carolinus* Erichs. being used in view of the recent paper of Hay ('02).

in a slightly oblique direction, with two or three turns, to a depth of about fourteen inches, where it ended in a pocket, with a capacity of over a pint, half filled with water, in which the animals were found. From the main shaft extended a number of passages. One of these branched, one branch ending in a low, closed chimney at the surface, while the other ended about an inch below the surface. The remaining side tunnels, one of which branched, ended in pockets, the capacity of one of which exceeded a quart. The entrance and exit to the pockets was by the same tunnel. That they were not the accidental result of a deepening of the tunnel, on account of the lowering of the water, but were constructed for some purpose, was shown by their size and form, and by the fact that in many cases the entrance was from below, as would not be the case were they the result of changes in the depth of the tunnel. At some places in Fern Hollow the ground was honeycombed with burrows, and it was sometimes possible to show that the tunnels of several chimneys were connected. In habits the animals are nocturnal, specimens being found in the traps set for small mammals.

Cambarus chaplanus Fax.

Mexico.

1. Lake Chapala, state of Jalisco. (F., '98.)

Cambarus clarkii Gir.

1. Alabama.

1. [Mobile bay], Mobile [Mobile county]. (F., '85.)

8. Florida.

1. Three miles below Horse Landing, St. Johns river [——— county]. (F., '85.)
2. [Pensacola bay], Pensacola [Escambia county]. (F., '85.)

17. Louisiana.

1. Tangipahoa river [Tangipahoa county]. (F., '85.)
2. [Mississippi R.], New Orleans [Orleans county]. (F., '85.)

23. Mississippi.

1. [Gulf of Mexico], Ocean Springs, Jackson county. (F., '85.)

34. Ohio.

?1. [Rocky R.], Olmstead (?) [Cuyahoga county]. (F., '85.)

42. Texas.

1. Clear creek, Waller county. (F., '85.)
2. [San Antonio R.], San Antonio [Bexar county]. (F., '85.)
3. Between San Antonio and El Paso del Norte. (F., '85.)
4. Las Moras creek, Kinney county. (F., '98.)

According to Faxon ('85), this is the species commonly on sale in the New Orleans markets.

Cambarus clypeatus Hay.

23. Mississippi.

1. Bay St. Louis [Hancock or Harrison county]. (Hay, '99.)

Cambarus compressus Fax.

1. Alabama.

1. Second creek, Waterloo, and Cypress creek, Lauderdale county. (F., '85.)

Cambarus cornutus Fax.

16. Kentucky.

1. Green river, near the Mammoth cave [Edmonson county]. (F., '85.)

Cambarus cubensis Erichs.

Cuba.

1. In creeks in a little town opposite Havana. (F., '85.)
2. Stagnant ponds in Cuba (*fide* Saussure, *C. consobrinus*). (F., '85.)

Cambarus difficilis Fax.

2. Arkansas.

1. [Trib. Illinois R.], Prairie Grove, Washington county. (F., '98.)

13. Indian Territory.

1. [Trib. Gaines creek], McAlester [Choctaw N.] (F., '98.)

Reported from tributaries of the Arkansas river.

Cambarus digueti Bouv.

Mexico.

1. Affluents of the Rio Santiago, state of Jalisco. (Bouvier, '97.)

Cambarus diogenes Gir.

2. Arkansas.

1. [Trib. Illinois R. or White R.], Fayetteville, Washington county. (F., '98.)
2. [Trib. St. Francis R.], Paragould, Greene county. (F., '98.)

5. Colorado.

1. [——— R.], Clear lake [——— county]. (F., '85.)
2. [St. Vrain R.], near Boulder [Boulder county]. (Harris, '00.)

7. District of Columbia.

1. [Potomac R.], near Washington. (F., '85.)

11. Illinois.

1. [Trib. Illinois R.], Lawn Ridge [Marshall county]. (F., '85.)
2. [Lake Michigan], Evanston [Cook county]. (F., '85.)
3. [Trib. Mississippi R.], Bellville [St. Clair county]. (F., '85.)
4. [Trib. Illinois R.], Decatur [Macon county]. (F., '85.)
5. [Spoon R.], Abingdon [Knox county]. (F., '85.)
6. [Lake Michigan], Chicago [Cook county]. (F., '85.)

12. Indiana.

1. Long lake, Kendallville, Noble county. (F., '85.)
2. [Trib. White R.], Mechanicsburg, Henry county. (F., '85.)
3. [Wabash R.], Knox county. (F., '85.)
4. [Trib. White R.], North Salem, Hendricks county. (Hay, '96.)
5. [White R.], Irvington, Marion county. (Hay, '96.)
6. Kankakee river, Riverside [—— county]. (F., '90.)
7. [Trib. Wabash R.], Kokomo [Howard county]. (F., '90.)

14. Iowa.

1. [Mississippi R.], Davenport [Scott county]. (F., '85.)
2. [Iowa R.], Belmond, Wright county. (F., '98.)
3. Spring creek, at Delhi, Delaware county. (F., '98.)

15. Kansas.

1. [Missouri R.], Leavenworth [Leavenworth county]. (F., '85.)
2. Kansas river, Lawrence, Douglas county. (Harris, '00.)

16. Kentucky.

?1. [Ohio R.], near Louisville [Jefferson county]. (F., '85.)
?2. Mill branch, near Bee Spring, Edmonson county. (F., '85.)

19. Maryland.

1. [Patapsco R.], Baltimore county. (F., '85.)
2. [Chesapeake bay or Potomac R.], St. Mary county. (F., '85.)
3. [Choptank R.], Caroline county. (F., '85.)
4. [Chesapeake bay], Dorchester county. (F., '85.)
5. [Assateague bay or Pocomoke R.], Worcester county. (F., '85.)
6. [Youghiougheny R.], Deer Park, Garrett county. (F., '85.)

21. Michigan.

1. [Lake St. Clair], Detroit [Wayne county]. (F., '85.)

22. Minnesota.

1. Minnesota river, at Fort Snelling [Hennepin county]. (F., '98.)

23. Mississippi.

1. [Pearl R.], Monticello, Lawrence county. (F., '85.)

24. Missouri.

1. [Mississippi R.], St. Louis [St. Louis county]. (F., '85.)
2. [Missouri R.], Carroll county. (F., '85.)

29. New Jersey.

1. [Delaware R.], Mercer county. (F., '85.)

32. North Carolina.

1. [Cape Fear R.], Wilmington [New Hanover county]. (F., '85.)
2. [Neuse R.], Kinston [Lenoir county]. (F., '85.)

?3. [Atlantic O.], Beaufort [Carteret county]. (F., '85.)

34. Ohio.

1. [Scioto R.], Columbus and Lockbourne, Franklin county. (F., '98.)
2. [Trib. Miami R.], around Oxford [Butler county]. (Hargitt, '90.)

37. Pennsylvania.

1. [Trib. Alleghany R.], Derry station, Westmoreland county. (F., '85.)
2. Ohio or Alleghany river, Fern Hollow, Pittsburgh, Allegheny county. (Williamson, '01.)

41. Tennessee.

?1. Mud chimneys resembling those of *C. diogenes* are found. (F., '85.)

45. Virginia.

1. [Potomac R.], Alexandria county. (F., '85.)
2. [Atlantic O.], Accomack county. (F., '85.)
3. [Atlantic O.], Northampton county. (F., '85.)
4. [Rappahannock R.], Fredericksburg [Spottsylvania county]. (F., '85.)
5. [Trib. James R.], Petersburg [Dinwiddie county]. (F., '85.)
6. [Potomac R.], Prince William county. (F., '90.)

48. Wisconsin.

1. Tributaries of Pecatonica river, Green county. (F., '85.)
2. [Fox R.], Appleton [Outagamie county]. (F., '85.)
3. [Lake Michigan], Racine [Racine county]. (F., 85.)

49. Wyoming.

1. [Trib. South Platte R.], Cheyenne [Laramie county]. (F., 85.)

Cambarus diogenes ludoviciana Fax.

17. Louisiana.

1. [Mississippi R.], New Orleans [Orleans county]. (F., '85.)

Audubon ('39) figures the chimney of a crayfish, probably *C. diogenes*. In describing the food habits of the white ibis, he says: "The crayfish often burrows to a depth of three or four feet in dry weather, for, before it can be comfortable, it must reach the water. This is generally the case during the prolonged heats of summer, at which time the white ibis is much pushed for food. The bird, to procure the crayfish, walks with remarkable care towards the mounds of mud which the latter throws up while forming its hole, and breaks up the upper part

of the fabric, dropping the fragments into the deep cavity that has been made by the animal. Then the ibis retires a single step and patiently waits the result. The crayfish, encumbered by the load of earth, instantly sets to work anew, and at last reaches the entrance to its burrow; but the moment it comes in sight the ibis seizes it with its bill."

Girard ('52), whose observations were made in the meadows in the vicinity of Washington, published quite extensive notes on the habits of this species. The substance of his observations is given below, quotations being freely used where condensation seemed inadvisable.

Of the burrows, he says: "The holes, as they appear at the surface of the ground, are nearly circular, from seven-tenths of an inch to one inch and one inch and a half in diameter. The depth of the burrows varies according to the locations; this we generally found to be from sixteen inches to two feet, and sometimes three feet and more. The construction of the burrow itself is often exceedingly simple; from the surface of the ground the excavation exhibits a gradual slope in direction, more or less undulating for a distance of from five to ten inches, when it becomes vertical for six or eight inches, and then terminates in a sudden, bottle-shaped enlargement, in which the animal is found, the bottom of the burrow having no subterranean communication, no other issue except towards the surface; it is entirely isolated from its neighbers, and leaves no chance for escape to its inhabitant. The same burrow may have several external holes connected with it, several inclined channels, which, however, meet at a depth where it becomes vertical. We found constantly the cavity full of water, but this was in March and April; the bottom, for several inches, was filled with soft and pulpy mud."

"There are other instances of burrows somewhat more complex. Their direction may be oblique throughout their whole extent, and composed of a series of chambers or ovoid enlargements, succeeding each other at short intervals· sometimes, also, and, connected with one of the chambers, a narrow and nearly vertical tubuliform channel extends downward to a much greater depth, and appears to us as a retreat, either during the cold winters or else during the dryness of the summer, when the water is low. That it is not for the mere purpose of

escaping pursuit, we infer from the fact that we repeatedly caught the animals in the chambers above, where they remain quietly instead of attempting to disappear into the apartments below."

He generally found a single male or female in a burrow, the latter, in March or April, carrying eggs. Sometimes, when very numerous, the windings of the upper part of the burrows would accidentally meet; each individual, however, seemed to remain in its own apartment.

A male and a female were found in one of the burrows. He was inclined to believe that the male goes in search of the female, since one was found "walking over the surface of the ground."

"In the spring, and, we are told, in the fall also, the burrowing crawfish builds over the holes of its burrow a chimney of the maximum height of one foot, but most generally lower. This chimney is circularly pyramidal in shape, is constructed of lumps of mud varying in size, irregularly rolled up one upon another, and intimately cemented together. Its exterior has a rough and irregular appearance, whilst the interior is smooth and as uniform as the subterraneous channel, having the same diameter as the latter. The cementing of the successive balls of mud is easily accounted for when we bear in mind that the latter are brought up in a very soft state, and that their drainage and subsequent solidification, on their exposure to the atmospheric air and rays of the sun, is all that is required to unite these parts."

As to the actual method of working he made no observations, except that the work was performed at night, and that the finding of the imprint of the second and third pairs of claws indicated that after the parcels of mud had been brought to the surface—probably "embraced between the chest and large claws, as suggested by Godman" ('60)—they were arranged and fixed in definite place by means of these organs.

"The closing of the aperture," he concluded, "is accomplished by bringing up several pellets of mud, depositing them temporarily on the edge of the chimney, and then drawing them back into close contiguity."

"The number of chimneys, distributed without regularity, in one particular locality, is often very great. We have seen localities where the holes could be traced from the edge of the

rivulets to the middle of the meadows; still, there being no subterraneous communication from one burrow to another, the animal, at any rate, would have to crawl out of the water and walk over land. Colonies of burrowing crayfish are found, we are told, in the interior of lands, far away from any rivulets of water, a circumstance which would lead to the supposition that these at least pass their entire lives in such localities, instead of spending one season in the water and another in dry lands. . . . For we learn from Mr. T. R. Peale, of Washington, that chimneys of mud, in all points similar to those just described, were observed by him in New Grenada, along the Rio Magdalena, several hundred miles from the seashore, and consequently indicating the presence of a species of crawfish which we do not hesitate in pronouncing distinct from *C. diogenes*."

According to Bundy ('77), a female of *C. obesus*, caught at the mouth of a tile ditch at Mechanicsburg, Ind., on New Year's day, 1876, had her abdominal appendages loaded with eggs nearly ready to hatch.

Bundy ('82 and '83) gives *C. obesus* as one of the largest and most abundant and preeminently the burrowing species of the region, *C. gracilis* having, according to Doctor Hay, the same habit. Unlike most other species, it prefers stagnant water, frequenting ponds and meadow ditches, often wandering far from bodies of water and burrowing in wet fields and swales. One burrow was followed twelve feet without reaching the end.

Tarr ('84) studied the habits of *C. diogenes* at the head of a small stream on the Virginia side of the Potomac, a few miles above Washington, in May, 1883. Many of his observations confirm those of Girard ('52), with whose work he was not improbably unacquainted, since he makes no references at all to other writers, while some are slightly different. As to the locality: "It was between two hills, at an elevation of 100 feet above the Potomac, and about a mile from the river. Here I saw many clayey mounds covering burrows scattered over the ground irregularly, both upon the banks of the stream and in the adjacent meadows, even so far as ten yards from the brook."

The variation in depth of the burrows mentioned by Girard ('52) seems to be explained by Tarr, who observed that at that time of the year the stream was receding and the meadow was beginning to dry, while not a month previous the meadow, at

least as far back as the burrows were found, had been covered with water. The burrows near the stream were less than six inches in depth, and there was a gradual increase in depth as the distance from the stream became greater. The holes farther from the stream were in nearly every case covered by a mound which, when they were far distant from the stream, was hard and dry, while those nearer had only a very small chimney, or none at all, and subsequent visits proved that at that time of the year the mounds were just being constructed. In the deeper holes, some of which reached a depth of three feet, he invariably found at various points enlargements which, he considers, represent the end of the burrow at some earlier period, the burrow being undoubtedly projected deeper as the water falls in the ground, for all burrows went down to water.

"The burrows near the stream were seldom more than six inches deep, being nearly perpendicular, with an enlargement at the base, and always with at least one oblique opening."

Tarr's description of the burrows corresponds well with that given by Girard. He also gives a diagram of a section of a typical burrow. "Occasionally the burrows are very tortuous, and there are often two or three extra openings, each sometimes covered by a mound." The burrows have a diameter of one and one-half to two inches, are smooth and of almost uniform diameter for the entire length.

Of the chimneys he says: "There is every conceivable shape and size in the chimneys, ranging from a mere ridge of mud, evidently the first foundation, to those with a breadth of one-half the height. . . . The mounds were usually of yellow clay, although in one place the ground was of fine gravel, and there the chimneys were of the same character. They were always circularly pyramidal in shape, the whole inside being very smooth, but the outside was formed of irregular nodules of clay, hardened in the sun, and lying just as they fell when dropped from the top of the mound. A small quantity of grass and leaves was mixed throughout the mound, but this was apparently accidental." In no case did he find the burrows connected. "Both males and females have burrows, but they were never found together, each burrow having but a single individual."

Tarr's explanation of the presence of an extra oblique opening is as follows: He thinks that the crayfish retire to the

streams in winter and construct their burrows in the spring for the purpose of rearing their young and escaping the summer droughts. He says: "I found one burrow which, on my first visit, was but six inches deep, and later had been projected to a depth of at least twice as great, and the inhabitant was an old female." He concludes that while the marsh is still covered with water after the winter has passed impregnation takes place and the burrows are immediately begun. At first the direction is oblique, and so long as the mouth is covered with water this is satisfactory, but upon the receding of the water a perpendicular burrow becomes more economical and this direction is maintained with more or less regularity, the perpendicular opening to the surface representing a shorter route for conveying the mud from the deeper excavation, the height of the mound over the vertical shaft depending upon the depth of the latter.

"About the middle of May the eggs hatch, and for a time the young cling to the mother. . . . After hatching, they must grow rapidly, and soon the burrow will be too small for them to live in, and they must migrate."

Tarr considered that the chimney was not "a necessary part of the nest," but only the mud brought up in digging. He carried away several chimneys, and no attempt was made to replace them but in one case, where, after removing the chimney, he partially filled the hole with mud, there was a simple half-rim of dried mud when the place was again visited, indicating that the burrow had been cleared soon after the first visit.

He says: "There is seldom more than a pint of water in each hole, and this is muddy and hardly suitable to sustain life. . . . How these animals can live for months in the muddy, impure water is to me a puzzle. They are very sluggish, possessing none of the quick motions of their allied *C. bartonii*, for, when taken out and placed either in water or on the ground, they move slowly. The power of throwing off their claws when grasped is often exercised."

Tarr leaves as a question the method of securing food. Evidently they do not "tunnel" for roots. "Food must be secured at night or when the sun was not shining brightly. In the spring and fall the tender stalks of meadow grasses would

furnish food, but when these become parched and dry, they must either dig after and eat the roots, or search in the stream."

Abbott ('84) does not agree with Tarr's ('84) conclusion that the "chimney" is simply the rejected material, but thinks that it is the product of design on the part of the animal, which "often studies the localities with care, and builds to suit the chosen site." His reasons for the conclusion are that on the sloping side of a ditch, where, had the material been simply rejected, it would have rolled down the bank, artistic towers two inches in diameter and from eight to eleven inches in height were erected. "In several instances the base of the tower was especially prepared for by having the ground leveled and smoothed before the foundation masses of *puddled* clay were put in position. Of a series of forty towers built by the *Cambarus diogenes* that I observed on the banks of a ditch, not one could have been the result of accident, as suggested by Mr. Tarr."

"The towers that were found in meadows at a considerable distance from open water were invariably broader at the base and never so high as those described on the edge of flowing water. These open-meadow towers or chimneys, however, were all found to be composed of pellets of clay so arranged as to render it highly improbable that their positions were fortuitous. Indeed, in the majority of instances it would have been practicable to have rolled the little balls of clay to a considerable distance from the opening of the tunnel."

Mr. Abbott suggests that the fact that some of the most elaborate structures are the result of the work of half-grown or even smaller crayfish may have a bearing on the question of design in "tower" building. "Some of the most slender and tallest were the work of diminutive little fellows, who certainly could have avoided a deal of labor if the chimneys or towers were not designed."

Abbott ('85) gives the results of the observations of his nephew, Mr. Jos. De B. Abbott, who, by the aid of a candle, observed the crayfish building his "chimney." According to him, the crayfish was seen to partially emerge from its burrow, bearing "on the back of its right claw a ball of clay mud which, by a dextrous tilt of the claw, was placed on the rim of the chimney. Then the crayfish remained perfectly still for a few

seconds, when it suddenly doubled up and dropped to the bottom of its burrow. There elapsed some three or four minutes between each appearance; but every time it came it brought a ball of clay and deposited it in the manner I have described. About two-fifths of the balls were not placed with sufficient care, and rolled down the outside of the chimney."

He believes that the closing of the orifice of the chimney is merely the result of the accidental falling in of pellets from the rim. In some localities where the burrowing crayfish abounds, there is a weather proverb to the effect that, when the crayfish closes the opening of his chimney in dry weather, there will be a rainfall within twenty-four hours.

Faxon ('85) characterizes *C. diogenes* as "preeminently a burrowing species, being found in meadows and clay bottoms, often at a great distance from any permanent stream." He quotes much of Girard ('52), and reviews Tarr ('84), and Abbott ('84), and states that he has been informed by Mr. P. R. Uhler that during the period of incubation the female goes into pools, ditches and quiet waters along the margin of overflowing creeks. He reviews Abbott ('85).

Holder ('86) discusses some habits of the crayfish, unfortunately omitting the name of the species. It was, however, probably *C. diogenes* or *C. gracilis*.

His observations were made in northern Illinois. Here he saw patches, sometimes several acres in extent, almost completely covered with small mounds eight to twelve inches high and six to twelve inches in diameter, flat on top, and nearly always grassed over the entire surface. So close were they that he could walk for considerable distance by stepping from one to the other.

He noticed that in these places the greatest number of mounds were usually close to a sluggish stream or low, damp place, radiating up the slope from here, the most distant heaps being perhaps 200 feet away. The animals were discovered by digging.

On the bank of a small river that flows through the prairie north of Freeport, he found numerous "heaps" formed in the black, clay mud, about four or five feet above the water-level. Nearly every one of these contained a crayfish living in water that "must have come from above," since the holes had no

connection with the river. The animals were generally found out of the water, just within the hole, and upon being alarmed would drop down. Having no chance to escape, "they were quite savage."

He believes that too much water is "disagreeable" to the animal, and that the "mounds," above and away from the streams, are the result of an attempt of the animal to obtain a location where he can safely remain in or out of the water. Since crawling out on an open bank would expose them to many dangers, they burrow in the saturated soil, "and at times penetrating from the stream bed." An opening is usually left on the side or at the top. The "mounds," he concludes, are usually built when the streams rise, the animals leaving the swift current and taking to higher ground for safety.

Mr. Holder was informed by a gentleman residing in Freeport that not many months before heavy rains had so greatly increased the volume of the little river that many quite large trees were almost submerged. When the water was at its height it was noticed that above water the trunks were completely covered with crayfish, which crawled up out of the water by hundreds, covering every available space.

He states that in certain portions of the Western country the work of the crayfish often greatly increases the difficulty of breaking up new land. Some farmers, however, consider that they enrich the land by keeping it open and in many other ways, and that land with the "crayfish heaps" is worth more per acre from this cause.

Hargett ('90) gives observations on the crayfish in the region around Oxford, Ohio. He mentions *C. gracilis* and *C. obesus*, and his observations probably apply, for the most part at least, to these species, although some may apply to a third form. He found them abounding in the streams of the adjacent country, where they might be observed at any time during at least eight months of the year, leaving the winter quarters at first sight of spring, and returning only with freezing weather in the autumn.

According to him, the best time for taking the "larger species of *Cambarus*, such as *gracilis*, *obesus*, etc.," was just at the spring thaw, especially during the usually accompanying period of large rainfall, when they "venture boldly forth" from their hibernating places "in the banks and fields adjoining sluggish

streams" . . . . "for the purpose of foraging, seeking new quarters, or more probably mating."

He refers to the question raised by Chaney ('89) about the feeding habits of the crayfish, and states that it will take living prey, as earthworms. In aquaria, they devoured in large quantities growing algæ and pondweed.

During the several weeks he kept in aquaria specimens of *C. obesus* and *C. gracilis* taken immediately upon "their first issuance from the state of hibernation," upon the breaking up of the severe winter of 1888; several pairs were noticed in copulation.

He never found them mating except in early spring, March and April, and sometimes in May, which is also the season of ovipositing. In only two instances was he able to get reports of females in "berry" at a later period than June; and in each case but a single specimen was found. "I have frequently found large males traveling considerable distance overland in the month of March to neighboring streams and ponds, doubtless in response to the sexual instinct, which is remarkably dominant at that time. In many cases the boldness with which such journeys were prosecuted in open daylight proved a fatal adventure, the daring subject falling a victim to the rapacity of the ubiquitous crow."

He had frequently taken specimens which had recently exuviated, and this was invariably in the spring, chiefly in May and early June. He also noticed perfect casts, which could not remain in such perfect condition during the winter, very commonly in the creeks in the spring and early summer.

Schufeldt ('96) observed the burrows of crayfish, probably *C. diogenes*, in southern Louisiana, especially in the vicinity of New Orleans. Some of his observations agree with those of Girard and Tarr, neither of whose writings he mentions. On a low plain south of New Orleans, he observed a great number of "chimneys" irregularly scattered over the entire meadow, but becoming markedly more numerous as one approached either side of a ditch. Some were short and flattened out; others reached the height of one foot and were uniformly built. In some places they stood in couples, side by side, but were usually separated from each other by eight or ten paces. All were built vertically, even when they stood on the sloping bank

of the ditch. A number of the taller ones, but more usually the lower ones, had their tops sealed over. The "chimneys" were evidently built up of "small pellets of mud laid on in a single course, the fusing together of the pellets depending somewhat upon the dryness of the ground when the structures were erected."

Of a burrow of *C. diogenes* in the neighborhood of Washington, D. C., he says: "Right on the bank of the stream I opened another; it only passed down eleven inches, when it terminated in a chamber about as big as my two fists, and placed at the side. It was below the water-level, and contained a fine living specimen of *C. diogenes*."

The "sealing-in" of the burrow, he found, was very thorough, the top being as thick as the walls, inside passage terminating "in a smooth, concave, hemispherical end." How and why the crayfish seals its burrow, he says, is as yet unexplained. "Possibly it may do this by backing up the burrow, and, by turning round and about, manipulate the moistened clay or mud into place by the use of its lateral tail fins and telson." As to the reason for sealing, he suggests that it may be that the orifice is sealed to prevent the upper rim from falling back into the burrow, to shut out rain or rising water, to prevent the attack of enemies, or while the parent is laying her eggs at the bottom of the burrow.

Schufeldt, like Tarr, believes that the chimney is not the result of design on the part of the animal, but is simply the most convenient and safe way of getting rid of the pellets.

Hay ('96), after giving some of the older observations, says: "The subterranean tunnels may sometimes be found to extend for several feet, and, as the animal frequently excavates them at some distance from water, they must reach a depth great enough to supply moisture sufficient for the need of the animal. During the dry months of the summer, however, they seem to lie in the end of their burrows in a sort of stupor. I have seen them fall from the end of an excavation, apparently lifeless, but capable of moving when put into water. In the early spring, when they come forth to breed, is the only season when they are a noticeable member of our fresh-water fauna. They move about chiefly at night, though I have frequently taken numbers of them from ditches and small streams on bright, sunny days.

Of a lot of thirty-five specimens collected on the evening of April 2, 1892, twenty-nine were males and six were females. At this date they were in copulation. Eggs were laid from April 18 to 30. I have frequently found females bearing well-grown young in small streams, and, therefore, do not think the habit of burrowing is adopted as a protection to the young generation, but rather to furnish a retreat during the dry summer months.''

The portion of Schufeldt ('97) dealing with the crayfish is practically a reprint from his other paper ('96).

Harris ('00) reports the taking of a female with swimmerets loaded with eggs in a not very late stage of development May 3. Since, in an examination of the same ditch four days later, he found many burrows in the bank, but no adult individuals in the open water, he considered that there was an indication that the eggs pass through the most of the stages of their development in the burrow, as is certainly the case with *C. gracilis*. In reporting material from Boulder, Colo. (5.2), he quotes a part of a letter from Francis Ramaley, as follows: ''We find crayfish here in ditches and ponds, much as in other localities, but as most of the ditches are dry part of the year, the animals are not abundant. Our streams are mostly swift-running, and crayfish are seldom found in them. I have not noticed the animals at high altitudes, but they may occur there, doubtless up to 8000 feet at any rate.''

See, also, colors of *Cambarus*.

Cambarus dubius Fax.

See *C. carolinus* Erich.

Cambarus erichsonianus Fax.

1. Alabama.

1. Big Cahawba river [Bibb, Perry or Dallas county]. (F. '98).

41. Tennessee.

1. Rip Roaring fork, five miles northwest of Greeneville [Greene county]. (F., '98.)
2. Estanaula creek, Athens [McMinn county]. (F., '98.)
3. Matlock Spring creek, near Athens [McMinn county]. (F., '98.)

Central Alabama and southeastern Tennessee, in tributaries of the Alabama and Tennessee rivers.

Cambarus evermanni Fax.

1. Alabama.

1. Escambia river at Flomaton, above Pensacola [Escambia county]. (F., '90.)

Cambarus extraneus Hag.

1. Alabama.

1. Big Cahawba river [Bibb, Perry or Dallas county]. (F., '98.)

9. Georgia.

1. Etowah river, Rome [Floyd county]. (F., '85.)

41. Tennessee.

1. Tennessee river, near the border of Georgia [——— county]. (F., '85.)

Cambarus extraneus girardianus Fax.

1. Alabama.

1. Cypress creek, Lauderdale county. (F., '85.)

41. Tennessee.

1. Eastanaula creek, near Athens [McMinn county]. (F., '98.)

Cambarus fallax Hag.

8. Florida.

1. St. Johns river, at Jacksonville [Duval county], Hawkinsville [——— county], Orange Bluff [——— county], Horse Landing [——— county], Blue Spring [Lake county], and Lake Jessup [Orange county]. (F., '85.)
2. [St. Johns R.?], Magnolia [Magnolia Springs, Clay county?]. (F., '85.)
3. St. Johns river, Orange county. (Lonnberg, '94.)
4. Sulphur springs, at Lake Jessup, Orange county. (Lonnberg, '94.)
5. Lake Eola, Orange county. (Lonnberg, '94.)
6. Fern creek, Orlando, Orange county. (Lonnberg, '94.)
7. Indian river [Brevard county]. (F., '85.)
8. [Indian R.], Titusville, Brevard county. (F., '85.)
9. [Trib. St. Johns R.?], Eustis, Lake county. (F., '98.)
10. [Trib. Suwanee R.], Gainesville, Alachua county. (F., '98.)

A species confined to the St. Johns and Indian river systems, except for the three questionable localities, one of which (8.10) seems to be in the territory drained into the Gulf of Mexico instead of the Atlantic ocean.

Lonnberg ('94) says: "Of this I collected specimens in the sulphur springs at Lake Jessup and in St. Johns river, in Lake Eola, in Fern creek, at Orlando, Orange county [Fla.]"

Faxon ('85) says: "Specimens were collected in Blue spring, St. Johns river [Fla.], a mineral spring impregnated with sulphur and magnesia—temperature, 70 deg. F. They were clinging to the under side of leaves.

See, also, *C. alleni*.

Cambarus forceps Fax.

1. Alabama.

1. Cypress creek, Lauderdale county. (F., '85.)

41. Tennessee.

1. [Trib. Tennessee R.], Knoxville [Knox county]. (F., '85 and '90.)
2. Clinch river, at Walker's Ford, eleven miles northwest of Tazewell [Claiborne county]. (F., '98.)
3. Bull's (or Big Sycamore) creek, tributary of Clinch river, seven miles south of Tazewell [Claiborne county]. (F., '98.)

45. Virginia.

1. Middle fork of Holston river, Glade Spring [Washington county]. (F., '90.)

Cambarus girardianus Fax.

See *C. extraneus girardianus.*

Cambarus gracilis Bundy.

11. Illinois.

1. [Trib. of Illinois R.], along watercourses, in early spring, in the neighborhood of Normal [McLean county]. (F., '85.)
2. [South fork Sangamon R.], Athens [Menard county]. (F., '85.)
3. [Trib. Illinois R.], Lawn Ridge [Marshall county]. (F., '85.)
4. [Mill creek or Wabash R.], York [Clark county]. (F., '90.)
5. [Trib. Illinois R. or Lake Michigan], neighborhood of Chicago [Cook county]. (Hay, '96.)

12. Indiana.

?1. Hay ('96) thinks that there is no doubt that the species will be found in the prairie region in the western portion of the state.

14. Iowa.

1. [Mississippi R.], Davenport, Scott county. (F., '85.)

15. Kansas.

1. [Trib. Verdigris R. or Neosho R.], Labette county. (F., '90.)
2. [Trib. Kansas R.], Douglas county. Stagnant ponds in early spring, and burrows later in summer. (Harris, '00.)

24. Missouri.

1. Tributary Mississippi river. I have found the chelæ of crayfish, undoubtedly this species, around stagnant ponds in St. Louis, St. Louis county.

?2. [—— R.], Day Brook, Jasper county. (F., '98.)

34. Ohio.

1. [Trib. Miami R.], region around Oxford [Butler county]. (Hargitt, '90.)

48. Wisconsin.

1. [Lake Michigan or trib. Illinois R.], prairies near Racine [Racine county]. (F., '85.)

Bundy ('82) states that it is found abundantly along watercourses in early spring at Normal, Ill., and that Doctor Hay

found it burrowing in the low grounds on the prairies [at Racine, Wis.], emerging from its holes at nightfall and after rains.

Faxon ('85) states that according to Dr. P. R. Hay, *C. gracilis* burrows in the clay in the prairies near Racine, Wis., and that Professor Forbes reports it as common along the watercourses in early spring in the neighborhood of Normal, Ill.

Being a burrower, *C. gracilis* is one of the species that is hard to obtain, especially the males, and this probably accounts for the meager reports of its distribution.

Mr. H. Garman says (Faxon, '85) that he has examined hundreds of specimens taken along watercourses in the neighborhood of Normal, Ill., and has not found a dozen males.

Hay ('95) says: "It is a burrower, coming forth probably only during the breeding season in the early spring, when it inhabits the watercourses."

Harris ('01) notes its presence in shallow, stagnant ponds in the neighborhood of Lawrence, Kan., in company with *C. virilis* and *C. immunis*. These ponds are usually very muddy, and have usually, in the shallow parts, which are apt to become dry during the summer, a rank growth of *Polygonum* and plants of like habit.

Harris ('00) records material as very plentiful in these stagnant ponds in early spring, but never knew of material being taken in running creeks. In one pond, which was carefully watched, the females appeared March 13, while the males were not found until April 15, when one was secured, another being taken some days later at the top of its burrow in a pasture not far from the pond. In August two males and one female were taken from the mouths of their burrows in a yard some distance from a running stream, but where the ground was low and inclined to be somewhat moist. The animal does not seem to be entirely nocturnal in its habits, and is not infrequently found at the top of its burrow in the daytime. The lowlands in which this species lives are frequently flooded at times of great rainfall, in which case the animals leave their burrows, and upon the subsidence of the water may be found wandering over the surface of the ground. The females of the species are olive-green in color, the males almost a salmon-red. The writer had been told by people from various parts of the state (Kansas)

of the numbers of red crayfish seen after a heavy, washing rain, and was inclined to consider the species widely distributed.

He considers that individuals of this species must exuviate in their burrows, since the ponds in which the females are found in the early spring were very carefully watched without finding a specimen which was at all soft from exuviation. In the spring females were occasionally found in these ponds with *a few* young which were nearly old enough to leave the parent. This makes it seem altogether probable that those females without young have lost them before or immediately upon taking to the open water. In *C. immunis*, the females exuviate in the spring as soon as the young abandon them, but this would seem to indicate that such is not the case with *C. gracilis*.

In the fall of 1900 there were many young crayfishes which seemed to be *C. gracilis* in the ponds, about October 20 to November 20 appearing in great numbers about the same time that *C. immunis* disappears. Young of this species were also noticed early in the spring of 1900. These young crayfish, which were from three-fourths to seven-eighths of an inch in length when they disappeared in November, 1900, appeared again about the 1st of March, 1901. They were taken in great numbers. A few days later the ponds froze over, but the animals were still to be found, apparently as plentiful as ever, under a layer of ice about an inch thick. They grew rapidly, and by the 1st of May had attained a length of from one to nearly one and one-half inches.

Many smaller animals of five-eighths of an inch in length were found in the ponds and ditches on May 9, probably the young of *C. gracilis*, which were still carried by the females as late as March 27. In the spring of 1901 the adults did not appear until after the young.

He did not succeed in determining the date of copulation or laying of eggs. The eggs in the ovaries of females taken in this way were by no means fully developed.

This species, as compared with some others, *C. immunis* for instance, he considers shows a very small percentage of mutilation, it being very seldom that an individual is found with one of the great claws wanting, or showing any indications of having been regenerated.

Harris ('02) records the finding of an adult female in a stag-

nant pond near Lawrence, Kan., in August, 1901, the only time he had ever taken an adult specimen in open water during the summer.

The males of this species must spend considerably more of their time in the burrows than do the females, as has been shown by the observation of Garman and Harris, who have seen only three adult males, all first-form, the adult second-form male being as yet unknown.

See, also, Hargitt ('90), under *C. diogenes*, and Holder ('86), under *C. diogenes*.

Cambarus hagenianus Fax.[16]

39. South Carolina.

1. Seaboard of Charleston [Charleston county]. (F., '85.)

Cambarus hamulatus Cope and Pack.

41. Tennessee.

1. [——— county], Nickajack cave. (F., '85.)

See Faxon ('85), under *C. pellucidus*.

Cambarus harrisonii Fax.

24. Missouri.

1. [Trib. Meramec R.], Irondale [Washington county]. (F., '85.)

Cambarus hayi Fax.

23. Mississippi.

1. Noxubee river [or Oaknoxubee creek], Macoun [Noxubee county]. (F., '85.)
2. [Trib. Tombigbee R.], Artesia [Lowndes county]. (F., '89.)

Cambarus hylas Fax.

24. Missouri.

1. West fork of Black river, Reynolds county. (F., '90.)

Cambarus immunis Hag.

1. Alabama.

1. [Trib. Tennessee R.], Huntsville [Madison county]. (F., '85.)

11. Illinois.

1. [Mississippi R.], Oquawka [Henderson county]. (F., '85.)
2. [Trib. Mississippi R.], Bellville [St. Clair county]. (F. '85.)
3. [Trib. Illinois R.], Lawn Ridge [Marshall county]. (F., '85.)
4. [Trib. Illinois R.], Normal [McLean county]. (F., '85.)
5. [——— R.], Aux Plains [——— county]. (F., '85.)

16. The adoption of the name *C. hagenianus* Fax., proposed by Faxon ('85) for Hagen's material, in case it should prove to be specifically distinct from Erichson's *C. carolinus*, has been shown to be necessary by Hay ('02).

12. Indiana.

1. White river, Marion county. (Hay, '96.)
2. Fall creek, Marion county. (Hay, '96.)
3. [White R.], Irvington, Marion county. (Hay, '96.)
4. Long Lake, Kendallville, Noble county. (Hay, '96.)
5. Wabash river, Posey county. (Hay, '96.)
6. Twin Lakes, Marshall county. (Hay, '96.)
7. Wabash river, New Harmony [Posey county]. (F., '90.)
8. [Wabash R.], Lafayette [Tippecanoe county]. (F. '90.)

14. Iowa.

1. [Iowa R.], West Liberty, Muscatine county. (F., '85.)
2. [Des Moines R.], Ames, Story county. (F., '98.)
3. Cedar river, Cedar Rapids, Linn county. (F., '98.)
4. Mapleton river, Mapleton, Monona county. (F., '98.)
5. Bryer river, Arion, Crawford county. (F., '98.)
6. [Iowa R.], Belmond, Wright county. (F., '98.)

15. Kansas.

1. [Trib. Smoky Hill R.], Ellis [Ellis county]. (F., '85.)
2. [Missouri R.], Leavenworth [Leavenworth county]. (F., '85.)
3. [Kansas R.], in stagnant ponds, Douglas county. (Harris, '00.)
4. [Kansas R.], in stagnant ponds on the prairie near Onaga, Pottawatomie county. (Harris, '02.)

21. Michigan.

1. Detroit river, Detroit [Wayne county]. (F., '85.)

22. Minnesota.

1. [Trib. Mississippi R.], Richfield, Hennepin county. (F., '85.)

24. Missouri.

1. [Mississippi R.], St. Louis [St. Louis county]. (F., '85.)

26. Nebraska.

1. [Platte R.], South Bend, Cass county. (F., '98.)

31. New York.

1. Small stream flowing into Oneida lake [——— county]. (F., '98.)

34. Ohio.

1. [Lake Erie], Sandusky, Erie county. (F., '98.)
2. Northern Ohio, near shore of Lake Erie. (F., '98.)

48. Wisconsin.

1. [Lake Michigan], Milwaukee [Milwaukee county]. (F., '85.)

49. Wyoming.

1. [Laramie R.], near Laramie [Albany county]. (F., '98.)

Mexico.

1. [——— R.], Orizaba. (F., '98.)

Cambarus immunis spinirostris FAX.

12. Indiana.

1. Streams of Vigo county. (Hay, '96.)

15. Kansas.

1. Ward's creek, Shawnee county. (F., '85*b*.)
2. Stagnant ponds, Douglas county. (Harris, '00.)

41. Tennessee.

1. [Trib. Mississippi R.], Obion county. (F., '85.)

Harris ('02) summarizes most of the literature on the habits of this species and presents his own observations. *C. immunis* has been reported from muddy ponds in Michigan (Faxon, '85), Minnesota (Herrick, '82), Illinois (Forbes, '76), and Indiana (Hay, '96). The material he examined seemed quite variable, and a part of it probably belongs to Faxon's variety *spinirostris*. In Douglas county, Kansas, where his observations were made, *C. immunis* is the most common species, being found in road-side ditches and stagnant ponds, and is exceedingly abundant in stagnant ponds in an old river-bed. These ponds are from six to eighteen inches deep, depending upon the dryness of the season, are very muddy, and have usually around the edges a rank growth of *Polygonum* and plants of like habit. From such a pond, one day in October, 1898, were taken about 1500 specimens, of which only a few were less than two and one-half inches in length. There were not more than a half-dozen small specimens in the whole lot, but other collections were made which showed the animals in all stages of development. In some of the ponds *C. immunis* seemed to be the only species, but in others it was found associated in predominating numbers with *C. gracilis* and *C. virilis* (?), but these do not occur in such great numbers as does *C. immunis*. According to him, *C. immunis* is a burrowing and, at least to a certain extent, a chimney-building species.

Hay's ('96) suggestion as to the perishing of the crayfish upon the drying up of the ponds seems to be due to lack of opportunity for examining the ponds in different conditions, since in many places which were examined, in all stages of drying up, no considerable number of dead ones were found. In early September, 1900, a pond which earlier in the season had contained many crayfish was found to contain few crayfish, but had many burrows around the edge. One of these, having a chimney about four inches high and five inches in diameter at the base, fifteen inches deep, and an inch and a half in diameter, with a cistern-shaped chamber about three and one-half or four

inches across at the bottom, was found to contain in this chamber a large first-form male and a somewhat smaller female. The burrow had apparently been carefully sealed by the animals. Some time later the pond was again examined, and no crayfish were found, but numbers of chimneys in various stages of disintegration were seen. In another pond containing more water, the crayfish were very abundant at about the same time. About the middle of October the locality was again visited; some of the burrows had chimneys, others were simply open at the top—probably old burrows whose chimneys had been disintegrated by the weather. The form of the chimney varies greatly. Sometimes the mud appears to be just thrown out on one side, then, after a considerable amount of material has accumulated, the remainder is thrown out wherever convenient, forming an irregular circular mound one to three inches high and six to nine inches across; sometimes a long ridge with a shaft in the middle is formed, the material being thrown out in two directions; while again the work sometimes seems to be discontinued before so much mud is removed to make it inconvenient to throw it all to one side, thus forming a crescent-shaped pile.

The largest chimneys noticed were about five inches high and three inches in diameter at the top. These were sometimes much inclined from the perpendicular. He concludes that for this species the theory of Tarr ('84) and Schufeldt ('97), that the chimney is simply material ejected from the burrow and not the result of a design on the part of the animal, is correct. Chimneys in presumably the same sort of locality as those described by Abbott ('84) were examined, and he could not convince himself that anything other than the easiest method of disposing of material could have prompted the animal to build a chimney-like structure. The mud is brought up in such a moist condition that there would be little danger of the pellets rolling down, as suggested by Abbott ('84). The amount of mud brought up sometimes is very considerable, amounting, in some cases, to as much as 200 cubic inches. The accidental sealing of the burrow would seem impossible. The opening through the chimney seems to be left till the last, when it is filled from the top, or near the top, to almost the level of the ground, where the shaft has a concave, hemispherical end, which is not

so smooth as Schufeldt's ('97) description would seem to indicate. Prints of the chelæ in the mud were noticed. One case, at least, was noticed, in which the shaft was filled with clay to somewhat below the surface of the ground.[17] The shaft usually goes straight down, but in some cases may be somewhat sinuous. They are quite deep, one being followed down four feet without reaching the end. He was not able to convince himself of the presence of a ledge upon which the animal could rest, as stated by Hubbard (Faxon, '84 and '85), for *C. argillicola*, although in some cases the burrow seemed to be expanded in a way which might serve for this purpose.

One case was noticed in which a lateral shaft originated about six inches below the surface and ended somewhat higher, about eighteen inches from its connection with the main shaft. It might seem that the animals do not like to stay under water very long, since, when an excavation extending somewhat below the water was made in one of the burrows, the animal two or three times came out of the water and darted back before an attempt to catch him was finally successful. The burrow was left for a few minutes, and when again examined a medium-sized female had crawled out of the water and was standing on the almost perpendicular side of the excavation. The theory that the burrows are made to escape the dry months of summer seems to be the correct one for this species, while, of course, the purpose of the burrows made or enlarged upon the approach of winter is evident. It is certain that they are not adopted as retreats while the eggs are being hatched, for females were taken in the open ponds in the fall, apparently soon after the eggs were laid, and they came out early in the spring, about March 20, to complete the process of hatching the eggs.

Harris ('02) reports material from a stagnant pond on the prairie, near Onaga, Pottawatomie county, Kansas. The ponds had been in existence about six years and had never been known to go dry. They probably had no connection during high water with the nearest creek, which was about a quarter of a mile away. No fish had ever been found in the ponds, but specimens of *Amblystoma tigrinum* Green, which is sometimes found in the same localities as *C. immunis* in Douglas county, were found.

17. I have since found numbers of burrows of this or other species in which this is the case, clay of a very different nature from that of the chimney, and apparently coming from a different stratum, being used.

The material was taken April 1, 1902. Some of the females were carrying eggs, but none were noticed with young.

Herrick ('96) records a large number of females, taken from a pond in Ann Arbor, Mich., on the 16th of November, when the ice was just beginning to form, as already in berry.

Cambarus indianensis Hay.

12. Indiana.

1. Patoka river, Patoka, Gibson county. (Hay, '96.)
2. [Patoka R.], Huntingburg, Dubois county. (Hay, '96.)

Hay ('96) says: "Concerning the habits of this species, I have been able to ascertain nothing. It probably is a form which frequents open water, much after the fashion of its close relative, *C. affinis*, of the East, of which Doctor Faxon was at first inclined to regard this as a variety."

Cambarus jordani Fax.

9. Georgia.

1. Etowah river, near Rome [Floyd county]. (F., '85.)

Cambarus lancifer Hag.

2. Arkansas.

1. St. Francis river, at Greenway [Clay county] and Big Bay [——— county]. (F., '98.)

23. Mississippi.

1. Root pond [——— county]. (F., '85.)
2. [Trib. Pearl R.], Vicksburg [Warren county]. (F., '98.)

Cambarus latimanus LeC.

1. Alabama.

1. [Trib. Black Warrior R.], Blount Springs [Blount county], Cullman [Cullman county], and Sand Mountain. (F., '85.)
2. [Tennessee R.], near Bridgeport [Jackson county]. (F., '85.)
3. [Trib. Black Warrior or Tennessee R.], Attalla, Etowah county.

9. Georgia.

1. [Trib. Oconee R.], Athens [Clark county]. (F., '85.)
2. [Oconee R.], Milledgeville [Baldwin county]. (F., '85.)
3. [Chattahoochee R.], Roswell [Cobb county]. (F., '85.)

23. Mississippi.

1. [Gulf of Mexico], Ocean Springs [Jackson county]. (F., '85.)

39. South Carolina.

1. [Reedy creek], near Greenville [Greenville county]. (F., '85.)
2. [Congaree R.], near Columbia [Richland county]. F., '85.)

41. Tennessee.

1. [Cumberland R.], near Ashland City, Cheatham county. (F., '85.)

Faxon ('85) says: "Mrs. C. L. Herrick collected small specimens at Ocean Springs, Miss., on the Gulf of Mexico, which appear to be this species, but its favorite habitats are the higher regions at a distance from the coast."

Cambarus lecontei Hag.

1. Alabama.

1. [Mobile bay], Mobile [Mobile county]. (F., '85.)

9. Georgia.

1. [Trib. Oconee R.], Athens [Clark county]. (F., '85.)

Cambarus longidigitus Fax.

2. Arkansas.

1. White river, Oxford Bend [——— county]. (F., '98.)

Cambarus longulus Gir.

32. North Carolina.

1. Spring creek, Hot Springs [Madison county]. (F., '90.)

41. Tennessee.

1. Watuga river, Elizabethton [Carter county]. (F., '90.)
2. [Tennessee R.], Knoxville [Knox county]. (F., '90 and '98.)
3. [Clinch R.], Cumberland Gap, [Claiborne county]. (F., '98.)
4. [Trib. French Broad R.], Greeneville [Greene county]. (F., '98.)
5. [Clinch R.], Tazewell [Claiborne county]. (F., '98.)

45. Virginia.

1. [Shenandoah R.], Waynesborough [or Waynesboro], [Augusta county]. (F., '90.)
2. Lick Run, James river [——— county]. (F., '90.)
3. North river, Lexington [Rockbridge county]. (F., '90.)
3. [Trib. Kanawha river], Wytheville [Wythe county]. (F., '90.)
5. South fork of Holston river, near Marion [Smyth county]. (F. '90.)

?6. [Trib. James R.], Bath county. (F., '90.)

47. West Virginia.

?1. [Trib. Kanawha R.], near White Sulphur Springs [Greenbrier county]. F., '90.)

Cambarus maniculatus LeC.

9. Georgia.

1. LeConte ('56) says: "Habitat cum priori." [*A. fossorum* = *C. troglodytes*.]

Cambarus medius Fax.

24. Missouri.

1. [Trib. Meramec R.], Irondale [Washington county]. (F., '85.)

Cambarus meeki Fax.

2. Arkansas.

1. Walnut Fork, Piney [Johnson county]. (F., '98.)
2. [Trib. of Illinois or White R.], Fayetteville [Washington county]. (F., '98.)

Reported from tributaries of the Arkansas river.

Cambarus mexicanus Erichs.

Mexico.

1. [——— R.], Mirador [———]. (F., '85 and '98.)
2. [——— R.], Santa Maria [———]. (F., '98.)
?3. [——— R.], "Les ruisseaux du Mexique. Pris a Tomatlan, dans les Terres Chaudes." Saussure's locality for *A. aztecus*. (F., '85.)
?4. [——— R.], Pueblo. Locality for *A. aztecus*. (F., '85.)

Cambarus mississippiensis Fax.

23. Mississippi.

1. Eastern Mississippi. (F., '85.)
2. [Oaknoxubee creek], Macon [Noxubee county]. (F., '85.)

Cambarus montezumæ Saussure.

Mexico.

1. [——— R.], marshes of the valley of Mexico. (F., '85.)
2. [——— R.], Chapultapec. (F., '85.)
3. Lake Tezcoco, near city of Mexico. (F., '85.)
4. [———], Pueblo. (F., '85.)
5. Lake San Roque, Trapuato. (F., '85.)

According to Faxon ('85), Lake Tezcoco is said to be salt.

Cambarus montezumæ areolatus Fax.

Mexico.

1. [——— R.], Parras, Coahuila. (F., '85 and '98.)

Cambarus montezumæ dugesii Fax.

Mexico.

1. [———], State of Guanajuato. (F., '98.)

Cambarus montezumæ occidentalis Fax.

Mexico.

1. [———], Mazatlan. (F., '98.)

Bouvier ('97) says of *C. montezumæ:* "Elle est répresentée dans les envois de M. Diguet par le varieté *tridens* sous sa form la plus nette, et prouvient soit de Guanajuato où elle habite les eaux courantes, soit des envoirons de Guadalajara (état de Jalisco) ou elle fut trouvée en grande abondance dans la source de *l'aqua azal,* au mileau des racines des naiadés."

Cambarus nais Fax.

15. Kansas.

1. [Verdigris or Neosho R.], Labette county. (F., '85 and '90.)
2. Small branch of Coal creek, Montgomery county. (Harris, '00.)

A species reported from the southwestern portion of Kansas, drained by the tributaries of the Arkansas river.

Harris ('00) reports this species from a rocky creek in southern Kansas—branch of Coal creek, Montgomery county. The creek winds between sandstone hills and is fed by many springs. It is of varying depths, being in some places eight or ten feet deep, while a short distance away it will be only a few inches. It sometimes goes dry in places, due, no doubt, to the failure of some of the springs that feed it.

Cambarus nebrascensis Gir.

26. Nebraska.

1. [—— R.], Fort Pierre [—— county]. Known only from the description of Girard ('52).

Cambarus neglectus Fax.

2. Arkansas.[18]

1. [White R. or trib.], Batesville, Independence county. [F., '98.)
2. [Trib. Illinois R. or White R.], Fayetteville, Washington county. (F., '98.)
3. [Trib. Illinois R.], Prairie Grove, Washington county. (F., '98.)
4. Spring creek, Johnson [Washington county]. (F., '98.)

14. Iowa.

1. Turkey river, Fort Atkinson, Winneshiek county. (F., '98.)

15. Kansas.

1. Mill creek, Wabaunsee county. (F., '90.)
2. Republican river, near Guy, Cheyenne county. (F., '90.)
3. Sappa creek, Oberlin, Decatur county. (F., '90.)
4. Wildcat creek, about two miles west of Manhattan, Riley county. (Harris, '02.)

?5. See *C. virilis* 15, ?27.

24. Missouri.

1. Clear, rocky stream, about four miles northwest of Springfield, Greene county. (Harris, '02.)
2. Stream flowing from Galloway cave, Galloway, Greene county. (Harris, '02.)
3. James river, near Galloway, about eight miles southeast of Springfield, Greene county. (Harris, '02.)

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18. A. W. Purdue, department of geology, University of Arkansas, writes me: "The water of the streams of north Arkansas is usually clear at average stage, and, being supplied largely by springs, is, I should judge, much below the average temperature of streams in this latitude. The water is rather swift, and flows in many places over rock bottom, but of course there are places where the bottom is mud. I have noticed that the springs of north Arkansas, which are cold enough for pleasant draughts during the hot summer days, are filled with small crayfish. . . . Illinois and White rivers are never connected, even during the highest water."

4. James river, Springfield [Greene county]. (F., '98.)
5. [Trib. Neosho or Grand R.], Day Brook, Jasper county. (F., '98.)
6. [Hickory creek], Neosho, Newton county. (F., '98.)

42. Texas.

1. Red river, Arthur [Lamar county]. (F., '98.)

Harris ('02) made some observations on the habits of this species near Springfield, Greene county, Missouri, during the early part of June, 1901. (24, 1, 2, and 3.) In the James river, near Galloway, about eight miles southeast of Springfield, this was the only species observed, although probably not the only one occurring in the river. At this place the James river is a rather swiftly flowing stream, with rocky bed, quite shallow in the swiftly running places, and with rather high wooded hills along the sides.[19] Crayfish were quite abundant, being found under loose stones and resting in the strands of rich vegetation,[20] which stood almost horizontally in the swiftly running water. Around Boiling Springs, where one of the cool, subterranean rivers of the region breaks through the rocky bed of the stream, they were very plentiful.

In a clear, rocky stream, about four miles northwest of Springfield (24, 1) crayfish were found in abundance, the smaller and more numerous species being *C. neglectus*, and were very active, darting from stone to stone when disturbed, but usually remaining under cover but a short time. In the stream flowing from Galloway cave (24, 2) *C. neglectus* and *C. rusticus* were taken, the former being the more abundant, if not the only species found at the mouth of the cave, where it occurred in great abundance under the small, loose stones. Here the water has practically the same temperature as that within the cave, which is said to remain at 57 deg. F. winter and summer. The animals were very inactive, the cold water, apparently, numbing them to such an extent that it was not at all difficult to take them with the hand.[21] A little distance down the stream, where the water was warm, the animals were noticed to be as active as usual. A striking effect of the low temperature seems to be seen in the hatching of the eggs. Many of the

19. Broadhead ('74) says of the streams of southwestern Missouri: "Those flowing through the Lower Carboniferous rocks of the southwest are clear, full, and rapid, and afford a mighty water-power. Among them are Spring river, Centre creek, Shoal creek, James's Fork of White river, Wilson's creek, Finley creek, and the head streams flowing into the Sac river."

20. Probably *Fontinalis*.

21. The water here, he states, is probably not more than fifteen degrees above that in which Harris ('02) found *C. virilis* so numb as to be almost incapable of movement.

females taken at the mouth of the cave were carrying eggs or recently hatched young, while none of those taken in the other localities were found with young at all. He thought that he found young crayfish which had but recently left the female in the vegetation near Boiling Springs, in the James river.

The distribution of this species is very interesting. It is found in the territory drained by the Mississippi in Iowa, Missouri, Kansas, Arkansas, and Texas. In Iowa it is reported from the very northeastern part, from a stream emptying directly into the Mississippi. In Missouri it is reported from the southwestern part, in the territory drained by the James river, in Greene county (24—2, 3, 4), which passes almost directly south into the White river, which crosses Arkansas diagonally and empties into the Mississippi with the Arkansas. In the northern part of Greene county (24.1) the drainage is toward the northeast and into the Missouri river, by way of the Osage river. The most southwestern localities (5, 6) are drained into the Arkansas through the Neosho or Grand river in Kansas and Indian Territory. In Arkansas it is found in the White river (1) in the north-central part and in the northwest (2, 3, 4) in the territory drained into the Arkansas by the Illinois river a little east of the Osage. In Texas it is reported from one locality, the Red river. In Kansas, *C. neglectus* is quite closely confined to the Republican river valley, being found, however, towards the east in some of the immediate tributaries of the Kansas river.

The interest lies in the widely separated localities from which the species has been reported. The character of the streams of the Ozark mountains, from which this species has been most frequently recorded, is well known, and from the limited information at hand the Turkey river seems to have some characteristics in common with them. While in the main it seems to occur in the upper waters of streams there are exceptions to this rule, and some of the localities from which it has been reported show that it is not exclusively confined to characteristic mountain streams.[22]

22. Under *C. neglectus*, Harris ('02) says of the Republican river: "The Republican river, in Cheyenne county, wherever I have seen it, is a shallow stream, perhaps 50 to 100 feet wide, with a bed of loose sand. It sometimes, though rarely, goes dry in places so far as the surface is concerned, but it is said that water can always be found by digging a few inches into the sand of the river-bed." I know nothing of the character of Sappa creek, but Mill creek is said to be a muddy stream, with occasional rock riffles. The character of the Red river is known, but the material recorded from that place may have been washed down from the head waters of the streams where it is so abundant.

Cambarus obscurus Hag.

31. New York.

1. Genesee river, Rochester [Monroe county]. (F., '85.)

37. Pennsylvania.

1. [Alleghany or Youghioughany R.], Westmoreland county. (F., '98.)

Hagen ('70) thinks *C. obscurus* may be identical with *A. fossor* Raf. Rafinesque says of *A. fossor:* "It burrows in meadows and willows, which it perforates and damages."

Cambarus palmeri Fax.

2. Arkansas.

1. St. Francis river, at Greenway [Clay county], and Big Bay [——— county]. (F., '98.)
2. Black river, at Black Rock [Lawrence county]. (F., '98.)
3. [Trib. St. Francis R.], Paragould, Greene county. (F., '98.)

41. Tennessee.

1. A brook running into the eastern side of Red Foot lake, near Idlewi'd hotel, Obion county. (F., '85.)

Cambarus palmeri longimanus Fax.

13. Indian Territory.

1. [Trib. Kiamichi R.], Good Land [or Goodland], [Choctaw Nation]. (F., '98.)
2. Walnut creek, Kainister. (F., '98.)

42. Texas.

1. [Red R.], Arthur [Lamar county]. (F., '98.)

Reported from a limited territory in southern Indian Territory and northern Texas, the Red river (42.1) forming the boundary.

Cambarus pellucidus Tellk.

12. Indiana.

1. [——— R.], Shiloh cave, Down's cave, Dunnihue's cave, Lawrence county. (Hay, '96.)
2. [——— R.], cave at Clifty, Bartholomew county. (Hay, '96.)
3. [——— R.], cave near Paoli, and in Lost river. Orange county. (Hay, '96.)
4. [——— R.], Wyandotte cave, Wildcat cave, small cave near Wyandotte, and Marengo cave (?), Crawford county. (Hay, '96.)
5. [——— R.], caves in Harrison county. (Hay, '96.)
6. [——— R.], caves near Madison, Jefferson county. (Hay, '96.)

16. Kentucky.

1. [——— R.], Mammoth cave and other caves in Edmonson county. (F., '85.)

Cambarus pellucidus testii Hay.

12. Indiana.

1. [——— R.], Mayfield's and Truett's caves, Monroe county. (Hay, '96.)

The type of *Orconectis inermis* Cope was taken by Cope ('72 and '72*b*) from a pool in a cool, "lively" stream in a subterranean channel to which he had gained access by descending a well about twenty feet deep, in the neighborhood of the cave.

On May 5, several of the specimens of *C. pellucidus* taken in the Mammoth cave in November by Putnam ('75), and taken to Massachusetts, were still in good condition, although they had eaten very little since their capture, taking "only a few mouthfuls" of the bits of cooked meat, raw liver and bread crumbs given them. Putnam ('75) says: "The specimens of *Cambarus bartonii*, the eyed crayfish collected in the cave at the same time, on the contrary, are quite ready to eat, and at once seize any food offered to them. The difference in the action of the two species at such times is quite striking. The moment the water in the jar is disturbed, the eyed species rears itself upon its tail, thrown out its large claws, seizes the piece of meat or bread, and, hastily conveying it to its mouth, generally holds onto the morsel until it is all eaten. though this species will sometimes take but a bite or two and then drop the food, and I do not think it will touch the same piece again."

"The blind species, on the contrary, darts backward as soon as the food is dropped into the water, and then extends its antennæ and stands as if on the alert for danger. After a long while, sometimes from fifteen to thirty minutes, it will cautiously crawl about the jar with its antennæ extended, as if using them for the purpose of ascertaining danger ahead. On approaching the piece of meat, and *before touching it*, the animal gives a powerful backward jump and remains quiet for awhile. It then approaches again, and sometimes will go through this performance three or four times before it concludes to touch the article, and when it does touch it the result is another backward jump. After another quiet time, it again approaches, perhaps only to jump back once more, but when it finally concludes that it is safe to continue in the vicinity of the meat, it feels with its antennæ for awhile, and then takes the morsel in its claws and conveys it to its mouth I have twice seen the meat dropped as it was passed along the base of the antennæ, as if the sense of smell, or more delicate organs of touch seated at that point, were again the cause of alarming the animal. When the jaws once begin to work, the piece of

meat or bread, if very small, is devoured, but if a little too large only a few bites are taken and the food is dropped and not again touched, though the animal crawls over it and rests upon it without being in the least concerned. These actions are best noticed by feeding with raw liver and by not disturbing the crayfish for some days before. . . . If food is often presented, the crayfish, becoming accustomed to the disturbance and probably to the smell, pays no attention to it."

A female slightly less than two and one-half inches in length, taken in the cave November 13, "was perfect in all respects except the right large claw, which was represented by a rudimentary one, entirely useless to the animal, and so small as to be almost imperceptible." From November 14 to 24, in fighting with others in the same jar, she "lost the larger part of her antennæ, the third, fourth and fifth legs from the left side, the fifth from the right side, and two end joints of the third leg on the right side." On January 28 or 29 "she cast her shell, and came forth with a soft white covering, which was nearly two weeks in hardening. Then all of the legs or claws that were perfect before were of the same size, but in addition the great claw of the right side was developed to about one-half or two-thirds the size of its fellow, and was apparently of as much use. The two missing joints of the third leg on the right side were also developed, though not quite to their full proportions. The fifth leg on the right side and the third, fourth and fifth on the left side were now reproduced, but in a small and rudimentary manner; all the joints were present, but every part was reduced in size. The antennæ were reproduced about two-thirds their full size."

During the month of February the tips of the antennæ were accidentally broken, so as to reduce their length about one-third.

"April 20. The old shell is cast whole, as before, and with her new dress the crayfish has all her legs and claws nearly perfect. The great claw at the right side is now very nearly as large as that of the left. The tip of the third leg of the same side is fully perfected, and all the legs that were rudimentary before are now developed, apparently to their full proportionate size, with the exception of the last on the right side, which is not quite perfect, the two terminal joints being somewhat ru-

dimentary. The antennæ are reproduced, well formed, and of about their full length, though the one on the left side is not quite as long as the other."

"From these observations it will be seen that the parts, such as the legs and antennæ, are not reproduced in perfection on one shedding of the shell, but each time the shell is cast they are more nearly perfect than before, and that in this instance it has taken three moltings, one before the animal was captured, to bring the great claw nearly to its full size, and one more molting, at least, will be necessary in order to perfect this important member. The posterior legs, on the contrary, are perfected in two moltings, and in this case in about five months from the time they were lost. The antennæ are developed more rapidly and approach their full size in one molting, and reproduce lost portions in less than three months. Since its capture the animal has not increased perceptibly in size. . . ."

It will be noticed that the specimen exuviated two times within three months. "This milk-white specimen of *C. pellucidus* has not changed color after shedding its shell twice and living in the full light of day, and often for hours in the sunshine, for over five months. Between the two exuviations it fed not more than three or four times, and then upon only a small quantity of food."

In conclusion he says: "It is also interesting to record that extremes of temperature do not effect these crayfish from the cave, as my several specimens have several times been retained in a heated room, and again have been exposed for weeks to such intense cold as to freeze the water in their jars."

In a foot-note added at the time of going to press, nearly ten months after the specimens were taken, he says: "Another specimen of the blind species, of about the same size, is still alive, and has been exposed to full light of day since last November, has eaten but very little, and has not shed its shell. The small specimen of *C. bartonii* mentioned above as having molted [about February 20] has not increased in size nor changed in color since February, and is apparently in good condition."

In reference to the change of color upon exuviation, he found that "the young specimen of *C. bartonii* had the same color after shedding as before," and that the theory that the grayish

specimens of *C. pellucidus* are those which have recently shed their skins will not hold good, since his specimen of *C. pellucidus* was milk-white, both before and after shedding.

Shaler ('75) concludes, from the association of *C. pellucidus* and *C. bartonii*, and the light color which often characterizes cave forms of the latter, that the blind species is derived from the present outside form, with which it is connected by transitions, and supposes that the cave fauna is reenforced by interbreeding with that of the outside!

In connection with the study of the habits of the cave forms, it is of interest to note that Leydig finds that the external flagellum of the antennule, on which are located the cones to which he has ascribed an olfactory function, is composed of thirty-six segments. The cones are, for the most part, confined to the middle third of the flagellum, where there are seven to each segment, the number decreasing toward either end. He was unable to compare other species of *Cambarus*, but Wright ('84) follows out the suggested comparison, using *C. propinquus*, and finds that the external branch of the antennule is composed of eighteen or nineteen segments, of which the distal nine alone bear olfactory cones, and only five of them, the eleventh to the fifteenth, have the full number of eight on each joint. From this he concludes that *C. pellucidus* forms no exception to the conclusions which had been reached concerning the greater development of olfactory organs in cave-inhabiting species than in those with well-developed eyes.

Faxon ('85) discusses these results, but finds that in *C. propinquus* the number of segments in the external flagellum may be as high as thirty-five, and of these fifteen or sixteen may carry olfactory organs. In *C. affinis* as many as thirty-three segments are counted, and nineteen of these are provided with olfactory setæ, while a moderate-sized *C. blandingii* from New Jersey shows about fifty segments, twenty-nine of which are provided with setæ. It thus seems that Wright's conclusions are not supported by the facts. He calls attention to the interesting fact that in *C. pellucidus* the olfactory setæ are better developed than in most species of *Cambarus*. In the specimen of *C. hamulatus* examined he finds thirty segments in the outer flagellum, and the olfactory setæ are long, as in *C. pellucidus*.

Faxon ('85), finding a small specimen in a jar containing *C. putnami* from Green river, near the Mammoth cave, concludes that the blind species sometimes finds it way out of the cave.

During the summers of 1891 and 1892, Hay ('93) made observations on the blind crayfishes of southern Indiana. Material was collected in Monroe, Lawrence and Orange counties. Between the localities visited in Monroe and Lawrence counties no material was obtained, owing to the heavy autumn rains, which had so muddied the subterranean streams as to obscure everything in them. In Shiloh cave, Lawrence county, he found them very common. He says: "The cave is a capacious one, and is traversed by a good-sized stream which will average a foot in depth. The bottom is of gravel, and full of small stones, which have fallen from the ceiling. A few crayfish were found here, but it was in a small branch running into the large stream about an eighth of a mile from the entrance of the cave that they were most abundant. The bottom of the branch is composed almost entirely of an exceedingly fine clay, with here and there a large rock that affords a ready resting-place for the animals."

"When first observed, the crayfish were generally, I might almost say always, resting quietly in some shallow part of the stream on one of the banks of clay. They lay with all their legs extended and their long antennæ gently moving to and fro. Once or twice I saw them on the shore a foot, at least, from the water, and one of these appeared to have been digging in the soft mud. When in the water I found it almost impossible to catch them with the net, and, after a few trials, threw it aside as useless. A much surer method was to approach them slowly with the hand and then suddenly seize them. When once touched they started off in great haste for some protecting rock, but often in their alarm would dart out on the bank, where they would lie, unable to get back to the water. They did not appear to be at all sensitive to the light. I have often tried the experiment of slowly passing my candle back and forth a few inches above them, or of suddenly removing the light and then bringing it close again, but with no effect whatever."

"Noise has no effect; a loud call or a shrill whistle they do

not notice, nor does disturbing the water seem to affect them, and it is only when they are touched that they manifest fear."

"The larger of these crayfishes could inflict a pretty severe nip with their pincers, but they did not appear to be as strong in this regard as the outside species."

Material from Mayfield's cave, Monroe county, Hay makes the types of a new subspecies, *C. pellucidus testii*.

Cambarus penicillatus LeC.

See *C. barbatus* Fax.

Cambarus pilosus Hay.

15. Kansas.

1. [Solomon R. or trib.], Beloit, Mitchell county. (Hay, '99.)
?2. Trib. Salt creek, Russell county. (Harris, '00 and '02.)

So far reported only from the north-central portion of Kansas.

Harris ('00) gives the following notes on the habits of specimens which he refers, with a little hesitation, to this species. "He [Mr. Sutton, who collected the material] found them July 14, burrowing under tussocks of grass on the edge of a small stream in Russell county, Kansas. A first-form male and a female were usually found in each burrow, both taking part in the work of excavation. The whole burrow was under water, running back at first horizontally, then sometimes downward at various angles. The burrows examined ranged from fifteen to to twenty-four inches in length, and were somewhat enlarged and sometimes branched at the end.

"In burrowing, the mass of mud was pushed out in front of the animal, being held between the anterior end of the animal and the chelæ, which were held with the inner margins close together, while the meros was held well up and close to the body, thus forming a sort of prismatic or pyramidal-shaped space between the chelæ and the anterior end of the thorax. Mr. Sutton was firmly convinced that the mass of mud was held between the chelæ and the body to prevent the mass from going to pieces while being moved along in the water, since when a stone was to be removed it was simply pushed along in front of the chelæ.

"As was stated above, the whole burrow was made under water, and no attempt was made to construct anything like a 'chimney' out of the mud removed. This was simply pushed

out of the mouth of the burrow, thus forming a 'dump' such as is frequently seen at the mouth of hillside coal-mines.

"The crayfish which build the regular 'chimneys' usually burrow at night, but these specimens were actively at work at noon, when they were taken."

It is interesting to note that the method which Mr. Sutton observed *C. pilosus* use in removing a stone from its burrow is essentially the same as that described nearly sixty years before for *C. bartonii* (?) by Godman ('42).

Harris ('02) adds that Mr. Sutton's material was taken in Kelp Fork, a "wet weather" stream of fresh water which flows into Salt creek, a tributary of the Saline river. At the time the material was taken water was not flowing from the pools into the creek. During the summer of 1901, Mr. Sutton took material from a well about five feet in depth, near the above region. The water from the pools, when high, would overflow into the wells.

Cambarus propinquus Gir.

Lake Superior. (F., '85.)

Canada.

1. [St. Lawrence R.], Montreal [Quebec]. (F., '85).
2. [Lake Ontario], Toronto [Ontario]. (F., '85.)

11. Illinois.

1. [Rock R.], Freeport, Stephenson county. (F., '85.)
2. [Rock R.], Ogle county. (F., '85.)
3. [Illinois R.], Geneva, Kane county. (F., '85.)
4. [Branch of Illinois R], Pekin, Tazewell county. (F., '85.)
5. [Trib. Illinois R.], Normal, McLean county. (F., '85.)
6. [Trib. Illinois R.], Decatur, Macon county. (F., '85.)
7. Aux Plains river. (F., 85.)

12. Indiana.

1. Elkhart river, Rome City, Noble county. (F., '85.)
2. [Trib. Wabash R.], Delphi, Carroll county. (Hay, '96.)
3. [White R.], Indianapolis, Irvington, and Millersville, Marion county. (Hay, '96.)
4. [Lake Michigan], Michigan City, Laporte county. (Hay, '96.,
5. Lake Maxinkukee and Twin Lakes, Marshall county. (Hay, '96.)
6. Turkey lake, Kosciusko county. (Hay, '96.)
7. Indian lake, Waterloo, De Kalb county. (Hay, '96, and F., '98.)
8. Turman creek, Sullivan county. (Hay, '96.)
9. [Wabash R.], Lafayette, Tippecanoe county. (Hay, '96.)
10. Clear creek, Bloomington, Monroe county. (F., '85, and Hay, '96.)
11. [Trib. White R.], Switz City, Greene county. (Hay, '96.)
12. [White Water R.], Brookville, Franklin county. (Hay, '96.)
13. Salt creek, Brown county. (Hay, '96.)
14. White river. (F. '85.)

14. Iowa.

1. Des Moines river, Ottumwa, Wapello county. (F., '85.)
2. [Mississippi R.], Davenport, Scott county. (F., '85.)

21. Michigan.

1. St. Clair river [St. Clair county]. (F., '85.)
2. Detroit river [Wayne county]. (F., '85.)
3. [Trib. Detroit R.], Northville [Wayne county]. (F., '85.)
4. Huron river, Ann Arbor [Washtenaw county]. (F., '85.)
5. Saginaw river. (F., '98.)
6. Lake Douglas [Cheboygan county]. (F., '98.)
7. [Lake St. Clair], Ecorse [Wayne county]. (F., '85.)
8. Kalamazoo river, Otsego [Allegan county]. (F., '85 and '90.)
9. [Kalamazoo R.], Marshall [Calhoun county]. (F., '90.)
10. St. Mary's lake, mouth of Battle creek [Calhoun county]. (F. '90.)

31. New York.

1. [Niagara R.], Niagara [Niagara county]. (F., '85.)
2. Grass river, St. Lawrence county. (F., '85.)
3. [Grass R.], Canton, St. Lawrence county. (F., '85.)
4. Black lake, St. Lawrence county. (F., '85.)
5. [St. Lawrence R.], Ogdensburg [St. Lawrence county]. (F., '85.)
6. Lake Ontario. (F., '85.)
7. Garrison creek, Sackett's Harbor [Jefferson county]. (F., '85.)
8. Four Mile creek, Oswego [Oswego county]. (F., '85.)
9. Oneida lake. (F., '85.)
10. Cayuga lake. (F., '85.)
11. [Lake Ontario]. Rochester [Monroe county]. (F., '85.)
12. [Lake Erie], Forestville, Chautauqua county. (F., '85.)

34. Ohio.

1. Portage river, at Oak Harbor, Ottawa county. (F., '98.)

37. Pennsylvania.

1. Alleghany and Monongahela rivers, and in many of the small streams throughout the county. Allegheny county. (Williamson, '01.)

48. Wisconsin.

1. Tributaries of Pecantonica river, Green county. (F., '85.)
2. [Trib. Rock R.], Madison [Dane county]. (F., '85.)

Cambarus propinquus sanbornii Fax.

16. Kentucky.

1. Smoky creek, Carter county. (F., '85.)

34. Ohio.

1. [Trib. Black R.], Oberlin [Lorain county]. (F., '85.)

Hay ('96) says: "This is probably the most abundant species in our state. It is usually found in large numbers in the smaller streams hiding under stones, concealed in short burrows along the banks, or resting quietly on the bottom." Ac-

cording to the same writer, Mr. Lewis McCormick reports *C. propinquus sanbornii* as the most abundant species at Oberlin, Ohio.

See, also, Faxon and Wyman, under *C. pellucidus*, and Hay, under *C. rusticus*.

Cambarus pubescens Fax.

9. Georgia.

1. McBean creek, tributary of the Savannah river, near Augusta, Richmond county. (F., '85.)
2. [Trib. Savannah R.], Richmond county. (F., '85.)
3. Buckhead creek, Millen, Burke county. (F., '98.)

Reported only from the territory of the two almost parallel rivers, Savannah and Ogeechee, in eastern Georgia.

Cambarus putnami Fax.

12. Indiana.

?1. [Trib. Ohio R.], Bradford, Harrison county. (Hay, '96.)
2. [White Water R.], Brookville, Franklin county. (Hay, '96.)
?3. [White R.], between Paoli, Orange county, and Wyandotte cave. (Hay, '96.)

16. Kentucky.

1. [Clinch R.], Cumberland Gap [Bell county]. (F., '85.)
2. Green river, near Mammoth cave [Edmonson county]. (F., '85.)
3. [Green R.], Grayson Springs, Grayson county. (F., '85.)

41. Tennessee.

?1. [Tennessee R.], Knoxville, Knox county. (F., '85.)

Cambarus rusticus Gir.

Lake Superior. (F., '85.)

1. Alabama.

1. Cypress creek, Lauderdale county. (F., '85.)

2. Arkansas.

1. White river, Eureka Springs, Carroll county. (F., '85.)
2. Black river, Black Rock [Lawrence county]. (F., '98.)

11. Illinois.

1. [Trib. Illinois R.], Normal [McLean county]. (F., '85.)
2. [Mississippi R.], Quincy [Adams county]. (F., '85.)

12. Indiana.

1. [White R.], Indianapolis [Marion county]. (F., '85.)
2. White river. (F., '85.)
3. Ohio river, Madison [Jefferson county]. (F., '85.)
4. White river and Irvington, Marion county. (Hay, '96.)
5. [Wabash R.], Waterloo, De Kalb county. (Hay, '96.)
6. [White Water R.), Brookville, Franklin county. (Hay, '96.)

14. Iowa.

1. Lizard creek, Fort Dodge [Webster county]. (F., '85.)
2. Shell Rock river, Waverly [Bremer county]. (F., '98.)
3. Indian creek, Marion [Linn county]. (F., '98.)

15. Kansas.

1. Osage river, La Cygne [Linn county]. (F., '90.)

16. Kentucky.

1. Kentucky river, Little Hickman [Jessamine county]. (F., '85.)
2. [Kentucky R.], Perryville, Boyle county. (F., '85.)
3. Salt river [Bullitt county]. (F., '85.)
4. [Mississippi R.], Moscow, Hickman county. (F., '98.)

21. Michigan.

1. [Shiawassee R.], Saginaw [Saginaw county]. (F., '98.)
2. [—— R.], Tiffin [—— county]. (F., '98.)

24. Missouri.

1. Osage river. (F., '85.)
2. [James R.], Springfield [Greene county]. (F., '98.)
3. [Osage or White R.], Marshfield [Webster county]. (F., '98.)
4. Meramec river, Dent county. (F., '90.)
5. Stream flowing from Galloway cave, Galloway, Greene county. (Harris, '02.)

34. Ohio.

1. Kelley's island, Lake Erie. (F., '85.)
2. Miami river, Dayton [Montgomery county]. (F., '85.)
3. Yellow Springs [Greene county]. (F., '85.)
4. Ohio river, Cincinnati [Hamilton county]. (F., '85.)
5. [Maumee R.], Grand Rapids, Wood county. (F., '98.)
6. [Maumee R.], Defiance, Defiance county. (F., '98.)
7. [Maumee R.], Ottawa, Putnam county. (F., '98.)
8. [Sandusky R.], McCutchenville, Wyandot county. (F., '98.)
9. [Sandusky R.], Tiffin, Seneca county. (F., '98.)

37. Pennsylvania.

1. [Ohio R.], Pittsburg [Allegheny county]. (F., '85.)
2. [Delaware R.], Philadelphia county. (F. '85.)
3. Ohio river, Neville island, Allegheny county. (Williamson, '01.)

41. Tennessee.

1. [Cumberland R.], Lebanon [Wilson county]. (F., '85.)
2. [Clinch R.], Cumberland Gap [Claiborne county]. F., '85.)
3. Harpeth river, Franklin [Williamson county]. F., '90.)

42. Texas.

1. In Texas. (F., '85.)

48. Wisconsin.

1. [Lake Michigan], Racine [Racine county]. (F., '85.)
2. [Trib. Mississippi R.], Beloit [Rock county]. (F., '85.)
3. [Trib. Wisconsin R.], Ironton [Sauk county]. (F., '85.)
4. Fox river (W. F. Bundy [*C. placidus*]). (F., '85.)

Hay ('96) says: "This species has very much the same habits as *C. propinquus*, and the two are often found in company."

Cambarus setosus Fax.

24. Missouri.

1. Wilson's cave and in wells, Jasper county. (Garman, '89, and Faxon, '90.)

?2. In stream from cave on branch of Finley creek, cave region of Christian county, near Ozark. (Broadhead, '74). Referred to this species on account of locality by Faxon ('90).

So far as yet known, this species is confined to the southwestern portion of Missouri. Jasper county (24, 1) is drained west into the Neosho or Grand river, which flows south through Indian Territory into the Arkansas, while Finley creek empties into James fork of White river, which enters the Mississippi at about the same point as the Arkansas. While in Greene county, Missouri, in the spring of 1901, I was told that there occur white crayfish in Galloway cave (for description see *C. neglectus*), but was unable to secure any specimens. The stream flowing from Galloway cave, at Galloway, about eight miles southeast of Springfield, empties into the James river, so that the two localities, about twenty miles apart, are directly connected by water. It may be that very light specimens of *C. neglectus* have been sometimes mistaken for "white crayfish."

C. setosus was described by Faxon in Garman's paper ('89), and again in his own paper ('90), from material collected in wells and caves in southwestern Missouri by Miss Ruth Hoppin.

Garman ('89) says: "The cave belt of Missouri is 150 or more miles in width, and extends diagonally quite across the state from northeast to southwest. . . . The geological position of the caves ranges from the St. Louis limestone of the Lower Carboniferous to the third magnesian limestone of the Lower Silurian. . . . The caves appear to become more extensive and more numerous toward the southwestern portion of the state. . . . The statement is made that Conner's cave, in Boone county, has been explored for a distance of eight miles. . . . The sink-holes with which so many of the caverns are connected prove the manner of forming to have been the same as that giving rise to the Mammoth and other caves of Kentucky. . . . There seems to be no reason to suppose

the history of the majority of these caves goes further back than that of the later Tertiary deposits, if so far. Such a small amount of divergence as exists between the species peculiar to the caves and their allies outside is proof that the former have entered their subterranean dwellings at a comparatively recent period."

The following notes, giving a quite fair idea of the surroundings, are quoted from Miss Hoppin's letters, published by Garman ('89) and by Faxon ('90) :

"Wilson's cave is about fifty feet long, nearly as wide, oven-shaped, and high enough to stand erect except around the sides, The farmer had enlarged the entry to use the place as a creamery. A small, very clear stream flowed along the left side, having a width of two feet and a depth of three, with a temperature of 54+ deg. F. About ten feet from the entrance, the light struck the stream in such a manner that we could see everything in the water without a lantern. The first things that caught the eye were a lot of white crayfish, a dozen in all, like those I took from the wells. It seemed as if I might take every one of them. But, though blind, they have one or more of the other senses very keenly developed. I am very sure they, as well as the white fishes [*Typhlichthys subterraneus* Gir.], have their tactile sense developed in an unusual degree. At the least touch upon the water they dart away. As the net cautiously follows, they escape adroitly, making no blunders as to the direction of the approaching enemy, and hide in crevices of the jutting rocks or in the muddy bottom of the stream. The mud was easily stirred so that nothing could be seen. These creatures, fish and crayfish, are only to be secured by patient waiting and skilful management. The people at the cave say the fish never bite, and cannot be taken with hook and line. The crayfish were all found near the entrance, where there is considerable light. Following the stream back to a dark recess, reached by crawling on the slippery rocks, the light of the lantern revealed a school of little, white fishes such as I secured from the wells. All were very small. I saw half a dozen or more, but secured only one. I concluded that the crayfish liked the light. Perhaps they remain near the entrance because they find there a supply of food. We found a few snails floating about, but saw none in the dark pool where the fish were.

Miss Wilson, who was with me, thinks the crayfish devour the others. She has never seen them together, and says the latter keep away from the former, though she had not noticed the crayfish catching or eating them. There was nothing to prevent the crayfish ascending the stream to where the others were."

. . . .

"On my first visit, the water being low, no crayfish were seen in the dark nook, the place favored by the fish. After the storm, which had flooded the caves, a few were found there. Though I watched for some time I never saw them pursue the fishes, as they might easily have done, guided by the stir in the water. Both creatures are very sensitive to the slightest ripple. During high water, a pool, 'the lake,' is formed a little way from the stream in another dark part of this cave. In low water this pool is cut off from the creek. I found both species in it, the fish in the darkest part, and saw no signs of enmity. Most of the crayfish were found in the lower part of the stream in the twilight; the fishes could not be found without the lantern. At the time of the floods the cave is full and the water rushes out furiously. Another proof that the crayfish are more fond of the light is seen in the shallower wells. That from which most were taken was more exposed to the sun. At noon, when the light was more favorable, we could see them swimming about. No fishes have been taken from this well. They are taken in the narrower, more shaded wells, of which the deep ones on the hills report fishes only.

"As to the food of the fishes, I discovered nothing. The mud where they were was not so deep as farther down. An examination of the length of the cave brought to light many snails; the shells of the living ones are whiter and more nearly transparent than the floating dead ones. The largest crayfish are of a dirty, rusty color, and very bristly, in caves and wells. One large one is very soft and very white. No doubt it is newly molted."

"Both fish and crayfish were less numerous after the freshet, and apparently less active. The disturbance of the flood may have caused them to retreat into their hiding-places, only the weaker being left behind, or some may have been swept away by the torrent. The sensitive creatures would soon die in the

light and heat outside, where the water is full of frogs and eyed crayfishes. . . . The specimens become opaque when put into alcohol; they are almost transparent when alive, so much so that the action of their internal organs can be observed. Repeated tests assured me the animals were blind, though very sensitive to the sunlight. They died soon after catching, even in water frequently changed."

"The wells from which specimens have been taken are about half a mile from Center creek, the water-level in wells and creeks being nearly the same. The wells were nine or ten in number, from five to eighty rods apart, from eleven to thirty feet in depth, deeper in the higher ground, and having a depth of water varying from two to four feet. In some wells the rock at the bottom had been excavated. The water is what is commonly called hard—*i. e.*, impregnated with lime. After rains some of the wells have softer water than others, and the water stands higher in these wells, indicating closer connection with surface-drainage. All of the wells soon regain the common level. They become low in times of drought, but never dry out entirely, as is the case with a cave spring near by, about twelve feet above the level of the creek. The temperatures taken in the wells at low water ranged from 52+ deg. to 54+ deg. F. During a storm, in the well having the highest water, the temperature rose to 57+ deg. When the mercury stood at 90 to 95 deg. outside the temperature was only 54 deg. in Wilson's cave."

Cambarus schufeldtii Fax.

17. Louisiana.

1. [Mississippi R. or Gulf of Mexico], near New Orleans [Orleans county]. (F., '85.)

Cambarus simulans Fax.[23]

15. Kansas.

1. [Trib. Smoky Hill R.], Fort Hays [Ellis county]. (F., '85.)
2. Tributary of Medicine Lodge river, Barber county. (F., '90.)
3. A slough near Halstead, Harvey county. (Harris, '00.)
4. A small branch of the Chikaskia river, six miles northeast of Caldwell, Sumner county. (Harris, '00.)
5. A stream near Wichita, Sedgwick county. (Harris, '02.)
6. A slough northeast of Caldwell, Sumner county. (Harris, '02.)

23. Professor Hay informs me that he has examined the types of *C. gallinus* Ckl. and Porter, in the United States National Museum, and concludes that the material should be referred to *C. simulans*. In this paper, the material described by Cockerell and Porter, and the material which I provisionally referred to *C. gallinus* in former papers, will be treated under *C. simulans*.

30. New Mexico.

1. Abundant in the Gallinas river at Las Vegas and in the neighboring waters [San Miguel county]. (Cockerell and Porter, '00.)
2. In lakes near Watrous [San Miguel county]. (Cockerell and Porter, '00.)
3. In irrigating canal at Roswell, Chaves county. (Cockerell and Porter, '00.)

42. Texas.

1. [Trinity R.], Dallas [Dallas county]. (F. '85.)
2. [Canadian or Red R.], east of Canadian river. (F., '85.)

Faxon ('84 and '85) reports this species in pools west of the hundredth meridian, east of the Canadian river, probably within the limits of Texas.

According to Cockerell ('00), and Cockerell and Porter ('00), *C. gallinus* is abundant in the Gallinas river, at Las Vegas, and in neighboring waters; also found in lakes near Watrous, N. M., and at Roswell.

The material arranged preliminary to *C. gallinus* by Harris ('00 and '02) was taken in a narrow strip of territory running north for about eighty miles from the southern boundary of Kansas and drained by the Arkansas river. Two small specimens, each slightly over an inch in length, were taken in a little running stream (Harris, '00). Material was taken in a slough near Halstead, Harvey county (Harris, '00), which connected in wet weather with a creek not a mile away. In July of 1900, when a part of the material was taken, the water was running more than usual, on account of recent rains, and no burrows were observed. About November 10, when the locality was again visited, specimens were taken from burrows. One of these, about one foot deep, had its mouth below the surface of the water. The others were along the bank, close to the water's edge. "Chimneys" were not very conspicuous. The burrows themselves, so far as noticed, were unbranched, about three inches in diameter, and extending almost straight down for a distance not to exceed one and one-half feet. One animal was found in each burrow.

A small slough four miles west of Caldwell, Sumner county (Harris, '02), had been dry all of the summer of 1901, owing to the very severe drought, but a spring a little distance from the edge still contained a small pool of water, perhaps three feet in diameter, although the water had ceased to flow into the slough. In the small pool were noticed a number of small specimens, about one inch in length, and, while none were taken, they undoubtedly belonged to the same species as the

adults taken in the same place. In digging a well in the old spring, eight adult specimens were secured, two males and six females. They had burrowed down through the loose surface soil for from six to thirty-six inches, depending upon whether the burrows were in the center or upon the edge of the old basin of the spring. The burrows, about two inches in diameter and provided with chimneys above, went down almost perpendicularly until they came to the surface of a stratum of Wellington shale. Here they were enlarged into almost round chambers, about ten inches in diameter, and not more than three inches in height. The crayfish had burrowed down a little ways into the rather disintegrated shale. The excavations of the shale were conical, about four inches in diameter at the top and four inches deep. In these chambers the crayfish, not very active or pugnacious when found, were taken. Mr. Kinnear, who collected the material, thought that as the shale was softened by the water the crayfish had removed it bit by bit. There were about three or four of the main burrows coming from the upper surface, terminating in the large chambers as described above. These chambers were then connected by passageways running from one to another. Two of the specimens were taken August 1 and the other six August 25–27.

All the females were, with one exception, loaded with eggs, which appear, on examination with a hand lens, to be in a very early stage of development, and have probably been only comparatively recently laid.

Prof. T. D. A. Cockerell, the author of *C. gallinus*, writes me as follows, November 5, 1902: "I have found remains of *C. gallinus* in the upper layer of our Pleistocene alluvium at Las Vegas, but as the creature burrows so much, I do not feel any assurance that the remains are really of the age of the deposit. They may very well be only a few hundred years old. The locality where they were found is not far from Green's lake, where the species still lives, and one has only to suppose that the lakes were formerly of larger size. At the same time, the creature may really have existed in the region when the deposits were formed."

In the same letter, Mrs. Cockerell, who is more familiar with the living animal, says: "These crayfish burrow in the muddy banks of the lakes and rivers where they live. We have col-

lected them from Green's lake, a semiartificial lake with mud bank, and the Gallinas river in the quiet pools. This river is a swiftly flowing mountain stream, with a rocky bottom in most places. Great numbers were found in the neighborhood of the irrigation dam. . . . Females taken in May had the swimmerets loaded with eggs."

In a letter of November 10, 1902, Mr. J. D. Tinsley, who collected *C. gallinus* at Roswell, N. M., informs me that he took his material in an irrigating canal when the water was quite low for a few hours. They were quite abundant and had burrowed considerable in the sides and possibly the bottom (?) of the canal below the usual water-level. He did not remember seeing any mud chimneys. The canal carries clear, very seldom muddy, water with a slow but decided current.

This species, then, is sometimes found in running streams and sometimes in burrows, apparently resorting to the burrow during dry weather.

Faxon ('85) says in his description: "The full cephalothorax and large abdomen seem to indicate that this is not preeminently a burrowing species, like its allies, *C. gracilis*, *C. advena*, etc."

Cambarus sloanii Bundy.

12. Indiana.

1. [Ohio R.], New Albany, Floyd county. (Hay, '96.)
2. [Ohio R.], Madison, Jefferson county. (Hay, '96.)
3. [Blue R.], Marengo, Crawford county. (Hay, '96.)

16. Kentucky.

1. In Kentucky (*fide* Bundy). (F. '85.)

So far as yet reported, it is confined to southeastern Indiana.

Hay ('96) says: "This species is quite abundant in southern Indiana, frequenting the muddy banks of running streams. Doctor Sloan, for whom the species was named, has made observations on its habits as follows: 'He commences on the bank of the stream, burrows below the bed, and has an opening two or more feet out in the stream, where he sits watching for anything that may turn up, with a safe retreat.'"

Cambarus spiculifer LeC.

9. Georgia.

1. Oconee river, at Athens [Clarke county], and Milledgeville [Baldwin county]. (F., '85.)
2. Ocmulgee river, in the neighborhood of Atlanta [Fulton county]. (F., '85.)
3. Chattahoochee river, at Roswell, Cobb county, and near Gainesville [Hall county]. F., '85.)
4. Etowah river. (F., '85.)

Cambarus spinosus Bundy.

1. Alabama.

1. Cypress creek, Lauderdale county. (F., '85.)
2. [Big Nance creek], Courtland [Lawrence county]. (F., '98.)

9. Georgia.

1. [Etowah, Oostenaula or Coosa R.], neighborhood of Rome [Floyd county]. (F., '85.)

32. North Carolina.

1. Tar river, Rocky Mount [Nash county]. (F., '90.)

39. South Carolina.

1. Saluda river. (F., '85.)

41. Tennessee.

1. Indian creek, tributary of Powell's river, six miles southeast of Cumberland. Gap [Claiborne county]. (F., '98.)
2. Clinch river, at Walker's Ford, eleven miles southwest of Tazewell [Claiborne county]. (F., '98.)
3. Tennessee river, near border of Georgia [Dode county (?)]. (F., '85)

Cambarus stygius Bundy.

48. Wisconsin.

1. Shores of Lake Michigan, having been washed up during a storm. (F., '85.)

Cambarus troglodytes LeC.

9. Georgia.

1. Lower Georgia. (F., '85.)
2. Savannah river, Richmond county. (F., '85.)

11. Illinois.

?1. [Trib. Illinois R.], Lawn Ridge, Marshall county. (F., '85.)

39. South Carolina.

1. [Atlantic O.], Charleston [Charleston county]. (F., '85.)
2. [Cooper R.], Oakley [Berkley county]. (F., '85.)
3. [Congaree R.], Columbia [Richland county]. (F., '85.)

LeConte ('56) says of *A. troglodytes:* "Habitat in Georgiæ Oryzaceis, ubi spiracula 4 unc. alta format"; and of *A. fossorum* [or *C. troglodytes*]*:* "Habitat in fossis Georgiæ inferiores."

Cambarus typhlobius Joseph.

Caves at Carniola. A species of especial interest, since it is the only one found outside of America.

Cambarus uhleri Fax.

19. Maryland.

1. [Assateague bay and Pocomoke R.], Worcester county. (F., '85.)
2. [Potomac R.], Somerset county. (F., '85.)
3. [Potomac R.], Wicomico county. (F., '85.)
4. [Chesapeake bay or Potomac R.], St. Mary's county. (F., '85.)
5. [Chesapeake bay], Talbot county. (F., '85.)
6. [Chesapeake bay], Dorchester county. (F., '85.)
7. [Choptank R.], Caroline county. (F., '85)

Faxon ('85) says: "This species was discovered in the counties of Maryland enumerated above, on the Chesapeake and Atlantic coasts of Maryland. It is found in salt marshes, covered twice daily by the tides, and also in brackish and fresh-water ditches in company with *C. blandingii.* In Dorchester county, it is found far back in the lowlands in the neighborhood of Vienna."

Cambarus versutus Hag.

1. Alabama.

1. [Mobile bay], neighborhood of Mobile [Mobile county]. (F., '85.)
2. [Escambia R.], Pollard [Escambia county]. (F., '98.)
3. [Trib. Coosa R.], Colora [Shelby county]. (F., '98.)
4. [Trib. Escambia R.], Greenville, Butler county. (F., '98.)
5. Escambia river at Flomaton [Escambia county], above Pensacola [Fla.] (F., '85.)

8. Florida.

1. [Pensacola bay ?], Cape Barrancas. (F., '85.)

Cambarus virilis Hag.

Canada.

1. Lake Winnepeg. (F., '85.)
2. Saskatchewan river. (F., '85.)
3. Red River of the North. (F., '85.)
4. [Lake Ontario], Toronto [York county]. (F., '85.)

?5. [St. Lawrence R.], Montreal. (F., '85.)

1. Alabama.

1. [Tennessee R.], near Bridgeport, Jackson county. (F., '85.)

2. Arkansas.

1. White river, Eureka Springs, Carroll county. (F., '85.)
2. [Trib. Illinois R.], Prairie Grove, Washington county. (F., '90.)
3. [Trib. Illinois R. or of White R.], Fayetteville, Washington county. (F., '90.)

11. Illinois.

1. [Illinois R.], Lawn Ridge, Marshall county. (F., '85.)
2. [Sangamon R.], Decatur, Macon county. (F., '85.)
3. [Trib. Illinois R.], Normal, McLean county. (F., '85.)
4. [Illinois R.], Pekin, Tazewell county. (F., '85.)
5. [Illinois R.], Geneva, Kane county. (F., '85.)
6. [Mississippi R.], Quincy, Adams county. (F., '85.)
7. [Mississippi R.], Cairo, Alexander county. (F., '85.)
8. Stillman's creek, Marion, Ogle county. (F., '85.)

12. Indiana.

1. Elkhart river, Goshen, Elkhart county. (Hay, '96.)
2. Twin Lakes, Lima, Lagrange county. (Hay, '96.)
3. Elkhart river, Rome City, Noble county. (F., '85, and Hay, '96.)
4. Lake Michigan, Michigan City, Laporte county. (Hay, '96.)
5. Long lake, Noble county. (Hay, '96.)
6. Turkey lake, Kosciusko county. (Hay, '96.)
7. [Kankakee R.], Shelby, Lake county. (Hay, '96.)

13. Indian Territory.

1. Five Mile creek, tributary of Spring river, one mile south of Kansas line, near Baxter Springs, Kan. (F., '90.)
2. [Trib. Gaines creek], McAlester [Choctaw Nation]. (F., '98.)

14. Iowa.

1. [Mississippi R.], Davenport [Scott county]. (F., '85.)
2. [Mississippi R.], Burlington [Des Moines county]. (F., '85.)
3. [Des Moines R.], Fort Dodge [Webster county]. (F., '85.)
4. Des Moines river. (F., '85.)
5. [Trib. Missouri R.], Bedford [Taylor county]. (F., '85.)
6. [Wapsipinicon R.], Springvale [Linn county]. (F., '85.)
7. Spirit lake, Dickinson county. (F., '98.)
8. [Des Moines R.], Ames, Story county. (F., '98.)
9. Storm lake, Buena Vista county. (F., '98.)
10. [Little Sioux R.], Cherokee, Cherokee county. (F., '98.)
11. Yellow creek, Pottsville, Allamakee county. (F., '98.)
12. Spring creek, Delhi, Delaware county. (F., '98.)
13. Boyer river, Arion, Crawford county. (F., '98.)
14. [Iowa R.], Belmond, Wright county. (F., '98.)
15. Shell Rock river, Waverly, Brenner county. (F. '98.)

15. Kansas.

1. Tributary of Kansas river, Shawnee county. (F., '85 *b*.)
2. Ward's creek, Shawnee county. (F., '85 *b*.)
3. [Kansas R.], Wabaunsee county. (F., 85 *b*.)
4. [Arkansas R.], Garden City, Finney county. (F., '85 *b*.
5. Leavenworth, Leavenworth county. (F., 85 *b*.)
6. [Kansas R.], Manhattan, Riley county. (F., '85 *b*.)
7. Republican river, northwest of Fort Riley. (F., '85 *b*.
8. [Smoky Hill R. or trib.], Ellis county. (F., '85 *b*.)
9. Sappa creek, Oberlin, Decatur county. (F., '90.)
10. Osage river, La Cygne, Linn county. (F., '90.)
11. [Kansas R.], Topeka, Shawnee county. (F., '90.)

12. Spring at head of Medicine Lodge river, Kiowa county. (Harris, '00.)
13. Stagnant ponds, Douglas county. (Harris, '00.)
14. Rock creek, Douglas county. (Harris, '00.)
15. Washington creek, Douglas county. (Harris, '00.)
16. Coon creek, Douglas county. (Harris, '00.)
17. Wild Horse creek, Jefferson county. (Harris, '00.)
18. [Trib. Kansas R.], in small stream, Dickinson county. (Harris, '00 and '02.)
19. A small branch of Chikaskia river, six miles northwest of Caldwell, Sumner county. (Harris, '00.)
20. Small stream near Egerton, Wyandotte county. (Harris, '00.)
21. Labette creek, within city limits of Parsons, Labette county. (Harris, '00.)
22. Wakarusa river, Douglas county. (Harris, '02.)
23. Bull Foot creek, Lincoln county. (Harris, '02.)
24. Spillman creek, Lincoln county. (Harris, '02.)
25. Wildcat creek, about two miles west of Manhattan, Riley county. (Harris, '02.)
26. Lower part of Kansas river, near Lawrence [Douglas county]. (Harris, '02.)

?27. Among some of my old notes I find that on March 29 or 30, 1895, I secured, in an irrigating ditch near Atwood, Rawlins county, four or five crayfishes, among which was one large female carrying a large number of eggs. On April 13, 1895, in the same ditch, was secured, hiding under a weed, another female with eggs. These specimens I place with this species, although it might just as well be *C. neglectus*; *C. neglectus* (3) and *C virilis* (9) having been taken at the same place, and *C. neglectus* (2) a few miles to the west. The eggs of *C. virilis* are carried in the spring (Harris, '00), as are also those of *C. neglectus* (Harris, '02). There is an error in the map given by Harris ('02), in that the 7 and the 10 should both be in Decatur county instead of the 7 in Decatur and the 10 in Rawlins county.

21. Michigan.

1. Spencer creek [——— county]. (F., '90.)
2. Barnum lake, south of Battle Creek [Calhoun county]. (F., '90.)
3. Lake Douglas [Cheboygan county]. (F., '98.)

22. Minnesota.

1. Lake Superior. (F., '85.)
2. Mississippi river. (F., '85.)
3. Lake Minnetonka [Hennepin county]. (F., '85.)
4. Minnehaha creek, Cedar Lake [——— county]. (F., '85.)
5. Bassett's creek and Lake Independence [Hennepin county]. (F., '85.)

24. Missouri.

1. [Mississippi R.], St. Louis [St. Louis county]. (F., '85.)
2. Osage river. (F., '85.)
3. Trib. Meramec R.], Irondale, Washington county. (F., '85.)
4. Bear creek and Hickson creek, Columbia [Boone county]. (F., '90.)
5. West fork of Black river, Reynolds county. (F., '90.)
6. [Trib. Neosho R.], Jasper county. (F., '98.)
7. [Trib. Neosho R.], Neosho, Newton county. (F., '98.)
8. [Missouri R.], Kansas City [Jackson county]. (Harris, '02.)

?9. Wells in Jasper county. (F., '90.)

26. Nebraska.

1. [Missouri R.], Omaha [Douglas county]. (F., '85.)
2. Blue river, Crete, Saline county. (F., '98.)

31. New York.

?1. Lake George. (F., '85.)

33. North Dakota.

1. Red River of the North, near Pembina [Pembina county]. (F., '85.)
2. Souris or Mouse river. (F., '85.)

41. Tennessee.

?1. [Tennessee R.], Lebanon [Marion county]. (F., '85.)

42. Texas.

1. Red river, Arthur [Lamar county]. (F., '98.)

48. Wisconsin.

1. [Fox R.], Appleton [Outagamie county]. (F., '85.)
2. Baraboo river, Ironton [Sauk county]. (F., '85.)
3. Wisconsin river, Sauk City [Sauk county]. (F., '85.)
4. Sugar river [Green county]. (F., '85.)
5. Rock river, Rock county. (F., '85.)
6. [Lake Koshkong], Jefferson [Jefferson county]. (F., '85.)
7. [Lake Michigan], Milwaukee [Milwaukee county]. (F., '85.)

49. Wyoming.

1. [Laramie R.], near Laramie City [Albany county]. (F., '85.)

Street's ('77) types of *C. cousei*, twenty-two in number, were taken from the stomach of a pelican shot in May, 1873, on the Red River, near Pembina (?). The bird was sick and not able to fly; so the crayfish were supposed to have been taken in that vicinity. He quotes Doctor Coues's notes on *C. virilis* collected in Souris or Mouse river, in Dakota: "In bed of stream among stones, in shallow water. Very abundant."

Bundy ('83) says: "One of our most abundant species, frequenting running streams."

Faxon ('90) reports two small specimens of *Cambarus*, with well-developed eyes, taken, together with *C. setosus*, by Miss Ruth Hoppin, in Jasper county, Missouri, as probably belonging to this species.

Hay ('96) reports *C. virilis* as being confined in Indiana to lakes and streams in the northern part of the state, where it is extremely abundant and attains a large size.

According to Harris ('00), *C. virilis* is found principally in running streams, although frequently taken in the same localities as *C. immunis*. While he never took *C. virilis* from burrows, he has no doubt that the great numbers of burrows which

are seen running back into the banks of the creeks just a little below the water line belong to this species. When living in the same sort of habitat as *C. immunis*, it doubtless burrows in the same manner. A specimen from Kansas City, Mo. (24, 8), was found by laborers nine feet under ground and considerably over 100 feet from water. *C. virilis* seems to prefer rocky rather than muddy places. May 5, 1900, he collected this species in Wild Horse creek, Jefferson county, Kansas. At the rocky riffles the crayfish were taken in abundance, but perhaps 150 yards above, where the bottom was composed of soft, deep mud, he did not secure a single specimen. The same thing was noticed in Coon creek, Douglas county, Kansas, and Mr. C. D. Bunker told him that in Rock creek, Douglas county, Kansas, he noticed that the animals are to be found only in the rocky places. Perhaps it finds among the rocks more ready protection from its enemies. So far as could be seen, food would be just as plentiful, if not more so, in the slower running, muddy parts of the stream than at the rocky riffles. *C. virilis* can and does live in muddy places. It is sometimes found in muddy ponds and roadside ditches with *C. immunis*, and he took a great many from Washington creek, Douglas county, Kansas, when the mud was as soft and deep as in either of the creeks mentioned above. In the winter *C. virilis* may be found under flat stones in the rocky creeks, even when the water is covered with ice. When taken from the water, they are so numb as to be almost incapable of movement, but liven up when held in the hand for a short time, and are as lively as ever after a few hours in the laboratory.

The eggs are laid in the spring, none being found on the females collected during the winter. The ovarian eggs of specimens taken in January seem to be fully developed, so far as may be seen from examination with the naked eye. Harris ('02) gives two lots of material as taken under stones in shallow running water.

Cambarus weigmanni Erichs.

Mexico.

1. **Mexico. (F., '85.)**

?2. [Gulf of Mexico], Jalapa [Jalapa]. (F., '85.)

?3. [Gulf of Mexico], Isthmus of Tehuantepec. (F., '85.)

DISTRIBUTION BY RIVER SYSTEMS.

In the following table the distribution of the different species by river systems is shown. The arrangement I have adopted is a simple one, the rivers emptying into the sea being arranged in order, from those of Hudson Bay to the Gulf of Mexico. Under each of these rivers, the tributaries are arranged in order from the mouth towards the source, and the tributaries of these are arranged in the same way. The names of streams flowing into the sea are printed in capitals; tributaries of the first, second and third order in small capitals, italics, and lower case, respectively. In some cases subdivisions have been made for large bays. In the case of the St. Lawrence river system, separate parts, as the Great Lakes and the Niagara river, have been most conveniently treated as separate tributaries of the St. Lawrence river as the term is generally understood.

Under the different streams are given alphabetical lists of the species reported from them, with references to the number of the state and the number of the locality in the state which is referred to this water system; *C. carolinus*, 41, 1, refers to "1. Clinch R., Cumberland Gap, Claiborne county. (F., '85)." In assigning certain localities to a drainage system, considerable difficulty has been experienced, especially in swampy regions, as northern Indiana and the most of Florida, but I feel confident that the most of the localities are correctly assigned. In many cases it has not been possible to determine from the localities given to what stream a species really belongs, and in the table it has been placed under both possible systems, the reference to the catalogue number followed by a question mark in parentheses, *C. bartonii*, 29, 2 (?), under both Raritan and Delaware rivers. The intention of this table is to place each locality in its proper drainage system. The species which are given under Atlantic ocean and Gulf of Mexico are from localities which could not well be assigned to any river, and probably all the localities are drained immediately into the ocean or swampy coast region.

The arrangement is in the main an artificial one, but it possesses certain advantages, and seems the best, all things consid-

ered. For certain localities it was impossible to determine the drainage system, and others, as those of *C. pellucidus*, it is not considered advisable to assign to streams. Of these species a list is given at the end of the table.

To facilitate use of the table, an index of species, the numbers referring to the numbers of the streams in the table, is given at the beginning:

INDEX OF SPECIES.

TABLE OF STREAMS.

1. **HUDSON BAY.**

2. NELSON RIVER.

3. LAKE WINNIPEG.

   C. virilis. C., 1.

4. SASKATCHEWAN RIVER.

   C. virilis. C., 2.

5. **ATLANTIC OCEAN.**

   C. barbatus. 39, ? 1.
   C. bartonii. 39, ? 1.
   C. blandingii. 19, 7; 32, 4; 45, 4.
   C. blandingii acutus. 32, 1; 39, 1.
   C. diogenes. 19, 5 (?); 32, ? 3; 45, 2, 3.
   C. hagenianus. 39, 1.
   C. troglodytes. 39, 1.
   C. uhleri. 19, 1 (?).

6. ST. LAWRENCE RIVER.
C. bartonii. C., ?1; 31, 2, 5.
C. bartonii robustus. 31, 4, 5, 8.
C. propinquus. C., 1; 31, 2, 3, 4, 5.
C. virilis. C., ?5.

7. RICHELIEU RIVER.

8. *Lake Champlain.*
C. bartonii. 31, 1; 44, 1.

9. Lake George.
C. virilis. 31, ?1.

10. LAKE ONTARIO.
C. argillicola. C., 1.
C. bartonii robustus. C., 1, 2; 31, 3.
C. propinquus. C., 2; 31, 6, 7, 8, 11.
C. virilis. C., 4.

11. *Oneida Lake.*
C. bartonii. 31, 10.
C. bartonii robustus. 31, 7.
C. immunis. 31, 1,
C. propinquus, 31, 9.

12. *Cayuga Lake.*
C. bartonii. 31, 11.
C. propinquus. 31, 10.

13. *Genesee River.*
C. bartonii. 31, 13.
C. bartonii robustus. 31, 2.
C. obscurus. 31, 2.

14. NIAGARA RIVER.
C. affinis. 31, 1.
C. bartonii. 31, 14.
C. propinquus. 31, 1.

15. LAKE ERIE.
C. affinis. (?).
C. argillicola. 34, 1, 2.
C. bartonii. 31, 15.
C. bartonii robustus. 31, 1.
C. blandingii acutus. 34, 1.
C. immunis. 34, 1, 2.
C. propinquus. 31, 12; 34, 1.
C. propinquus sanbornii. 34, 1.
C. rusticus. 34, 1.

16. *Sandusky River.*
C. rusticus. 34, 8, 9.

17. *Maumee River.*
C. rusticus. 34, 5, 6, 7.

18. *Huron River.*
C. propinquus. 21, 4.

19. DETROIT RIVER.
C. immunis. 21, 1.
C. propinquus. 21, 2, 3.

6. ST. LAWRENCE RIVER—*continued:*

20. LAKE ST. CLAIR.
    - C. argillicola. 21, 1.
    - C. diogenes. 21, 1.
    - C. propinquus. 21, 7.

21. ST. CLAIR RIVER.
    - C. propinquus. 21, 1.

22. LAKE HURON.
    - C. propinquus. 21, 6 (?).
    - C. virilis. 21, 3 (?).

23. *Saginaw River.*
    - C. argillicola. 21, 2.
    - C. propinquus. 21, 5.
    - C. rusticus. 21, 1.

24. LAKE MICHIGAN.
    - C. blandingii acutus. 11, 8; 48, 1.
    - C. diogenes. 11, 2, 6; 48, 3.
    - C. gracilis. 11, 5 (?); 48, 1 (?).
    - C. immunis. 48, 1.
    - C. propinquus. 12, 1, 4; 21, 6 (?).
    - C. rusticus. 48, 1.
    - C. stygius, 48, 1.
    - C. virilis. 12, 1, 3, 4, 5 (?); 21, 3 (?); 48, 7.

25. *Kalamazoo River.*
    - C. propinquus. 21, 8, 9, 10.
    - C. virilis, 21, 2.

26. LAKE SUPERIOR.
    - C. affinis.
    - C. bartonii robustus.
    - C. propinquus.
    - C. rusticus.
    - C. virilis. 22, 1.

27. RESTIGOUCHE RIVER.
    - C. bartonii. C., 5.

28. UPSALQUITCH RIVER.
    - C. bartonii. C., 6.

29. MIRAMICHI RIVER.
    - C. bartonii. C., 7.

30. ST. JOHN RIVER.
    - C. bartonii. C., 2, 3, 4; 18, 3, ? 6.

31. PENOBSCOT RIVER.
    - C. bartonii. 18, ? 5.

32. KENNEBEC RIVER.
    - C. bartonii. 18, 1, 3, ? 4.

33. PROVIDENCE RIVER.
    - C. bartonii. 20, 1.

34. PAWCATUCK RIVER.
    - C. bartonii. 38, ? 1.

35. HOUSATONIC RIVER.
C. bartonii. 20, ? 4.

36. HUDSON RIVER.
C. bartonii. 20, 2, 3; 31, 3, 4, 7.
C. bartonii robustus. 31, 6.

37. PASSAIC RIVER.
C. bartonii. 29, 3.
C. blandingii. 29, 1.

38. RARITAN RIVER.
C. affinis. 29, 1 (?).
C. bartonii. 29, 2 (?).

39. NAVESINK RIVER.
C. affinis. 29, 5.

40. DELAWARE RIVER.
C. affinis. 29, 1 (?), 2, 3, 4; 37, 2, 3, 7, 8.
C. bartonii. 29, 1, 2 (?); 31, 6, 8; 37, 8, 13, 14.
C. blandingii. 29, 2.
C. diogenes. 29, 1 (?).
C. rusticus. 37, 2.

41. SCHUYLKILL RIVER.
C. affinis. 37, 1 (?).
C. bartonii. 37, 7.

42. CHESAPEAKE BAY.
C. affinis. 19, 5, 7, 8.
C. bartonii. 19, 6 (?).
C. blandingii. 19, 5.
C. diogenes. 19, 2 (?), 4.
C. uhleri. 19, 4 (?), 5, 6.

43. POCOMOKE RIVER.
C. blandingii. 19, 6 (?).
C. diogenes. 19, 5 (?).
C. uhleri. 19, 1 (?).

44. WICOMICO RIVER.
C. blandingii, 19, 6 (?).

45. CHOPTANK RIVER.
C. blandingii. 19, 1, 2, 3.
C. diogenes. 19, 3.
C. uhleri. 19, 7.

46. SUSQUEHANNA RIVER.
C. affinis. 37, 4, 5, 6.
C. bartonii. 19, 6 (?); 31, 9, 12; 37, 2, 3, 4, 5, 6, 9.

47. PATAPSCO RIVER.
C. affinis. 19, 6.
C. blandingii. 19, 1.
C. diogenes. 19, 1.

48. PATUXENT RIVER.
C. bartonii. 19, 7.
C. blandingii. 19, 4 (?).

42. CHESAPEAKE BAY—*continued:*

49. POTOMAC RIVER.

C. affinis. 7, 1; 19, 1, 2, 3, 4; 45, 1.
C. bartonii. 7, 1, 2; 19, 1, 3, 4, 5, 8; 45, 10; 47, 4, 6, 7.
C. bartonii robustus. 19, 1.
C. blandingii. 19, 4 (?).
C. diogenes. 7, 1; 19, 2 (?); 45, 1, 6.
C. uhleri. 19, 2, 3, 4 (?).

50. *Shenandoah River.*

C. affinis. 45, 2.
C. bartonii. 45, 2, 12.
C. longulus. 45, 1.

51. RAPPAHANNOCK RIVER.

C. bartonii. 45, 9.
C. bartonii robustus. 45, 1.
C. diogenes. 45, 4.

52. JAMES RIVER.

C. bartonii. 45, 5, 7, 8.
C. blandingii. 45, 1, 3.
C. diogenes. 45, 5.
C. longulus. 45, 2, 3, ?6.

53. CHOWAN RIVER.

C. affinis. 45, 2.
C. bartonii. 45, 6, 11.
C. blandingii. 45, 2.

54. PAMLICO RIVER.

C. blandingii. 32, 1.

55. TAR RIVER.

C. blandingii. 32, 7.
C. carolinus. 32, 1.
C. spinosus. 32, 1.

56. NEUSE RIVER.

C. acuminatus. 32, 3.
C. argillicola. 32, ? 1.
C. bartonii. 32, 5.
C. blandingii. 32, 2, 3, 8.
C. diogenes. 32, 2.

57. CAPE FEAR RIVER.

C. acuminatus. 32, 4.
C. blandingii. 32, 6.
C. diogenes. 32, 1.

58. SANTEE RIVER.

59. CONGAREE RIVER.

C. blandingii. 39, 3.
C. latimanus. 39, 2.
C. troglodytes. 39, 3.

60. *Saluda River.*

C. acuminatus. 39, 1.
C. blandingii. 39, 2.
C. latimanus. 39, 1.
C. spinosus. 39, 1.

58. SANTEE RIVER—*continued:*

61. WATEREE RIVER.

C. blandingii. 39, 1.

62. *Catawba River.*

C. acuminatus. 32, 1, 6.

C. bartonii. 32, 3 (?), 4.

63. COOPER RIVER.

C. troglodytes. 39, 2.

64. SAVANNAH RIVER.

C. blandingii. 9, 1, 2.

C. pubescens. 9, 1, 2.

C. troglodytes. 9, 2.

65. OGEECHEE RIVER.

C. pubescens. 9, 3.

66. ALLAMAHA RIVER.

67. OCONEE RIVER.

C. latimanus. 9, 1, 2.

C. lecontei. 9, 1.

C. spiculifer. 9, 1.

68. *Ocmulgee River.*

C. spiculifer. 9, 2.

69. ST. JOHNS RIVER.

C. alleni. 8, 1, 5.

C. clarkii. 8, 1.

C. fallax. 8, 1, 2 (?), 3, 4, 5, 6, 9 (?), 10 (?).

70. INDIAN RIVER.

C. fallax. 8, 7, 8, 9 (?).

71. **GULF OF MEXICO.**

C. alleni. 8, 2, 4.

C. argillicola. 23, 1.

C. blandingii acutus. 42, 2.

C. clarkii. 23, 1.

C. clypeatus. 23, 1.

C. latimanus. 23, 1.

C. schufeldtii. 17, 1 (?).

C. weigmanni. M., ? 2, ? 3.

72. CALOOSAHATCHEE RIVER.

C. alleni. 8, 3.

73. PEACE RIVER.

C. alleni. 8, 6.

74. SUWANEE RIVER.

C. fallax. 8, 10 (?).

75. APPALACHICOLA RIVER.

76. CHATTAHOOCHEE RIVER.

C. latimanus. 9, 3.

C. spiculifer. 9, 3.

77. PENSACOLA BAY.
C. clarkii. 8, 2.
C. versutus. 8, 1.
78. ESCAMBIA RIVER.
C. barbatus. 1, 1.
C. bartonii longirostris. 1, 1.
C. evermanni. 1, 1.
C. versutus. 1, 2, 4, 5.

79. MOBILE BAY.
C. blandingii acutus. 1, 1.
C. clarkii. 1, 1.
C. lecontei. 1, 1.
C. versutus. 1, 1.
80. MOBILE RIVER.
81. *Tombigbee River.*
C. blandingii acutus. 23, 1.
C. hayi. 23, 1, 2.
C. mississippiensis. 23, 2.
82. Black Warrior River.
C. blandingii acutus. 1, 2, 3.
C. latimanus. 1, 1, 3 (?).
83. *Alabama River.*
84. Cahaba River.
C. erichsonianus. 1, 1.
C. extraneus. 1, 1.
85. Coosa River.
C. spinosus. 3, 1 (?).
C. versutus. 1, 3.
86. Etowah River.
C. extraneus. 9, 1.
C. jordani. 9, 1.
C. spiculifer. 9, 4.
C. spinosus. 9, 1 (?).
87. Oostanaula River.
C. spinosus. 9, 1 (?).
88. PEARL RIVER.
C. diogenes. 23, 1.
C. lancifer. 23, 2.

88*b*. LAKE PONTCHARTRAIN.
C. clarkii. 17, 1.
C. blandingii acutus. 17, 2, 3.

89. MISSISSIPPI RIVER.
C. argillicola. 17, ? 1.
C. blandingii acutus. 11, 5; 14, 2; 17, 1; 23, 2; 24, 1; 41, 1.
C. clarkii. 17, 2.
C. diogenes. 11, 3; 14, 1; 24, 1.
C. diogenes ludoviciana. 17, 1.
C. gracilis. 14, 1; 24, 1.
C. immunis. 11, 1, 2; 22, 1; 24, 1.
C. immunis spinirostris. 41, 1.
C. palmeri. 41, 1.

89. MISSISSIPPI RIVER—*continued:*
C. propinquus. 14, 2.
C. rusticus. 11, 2; 16, 4; 48, 2.
C. schufeldtii. 17, 1 (?).
C. virilis. 11, 6, 7; 14, 1, 2, 11; 22, 2, 3, 4; 24, 1.

90. RED RIVER.
C. blandingii acutus. 13, 1; 42, 1.
C. neglectus. 42, 1.
C. palmeri longimanus. . 13, 1; 42, 1.
C. simulans. 42, 2 (?).
C. virilis. 42, 1.

91. WASHITA RIVER.
C. blandingii acutus. 2, 3.

92. ARKANSAS RIVER.
C. carolinus. 13, 1.
C. meeki. 2, 1.
C. simulans. 15, 3, 5.
C. virilis. 15, 4.

93. *Canadian River.*
C. blandingii acutus. 13, 2, 3.
C. difficilis. 13, 1.
C. palmeri longimanus. 13, 2.
C. simulans. 42, 2 (?).
C. virilis. 13, 2.

94. *Illinois River.*
C. difficilis. 2, 1.
C. diogenes. 2, 1 (?).
C. meeki. 2, 2 (?).
C. neglectus. 2, 2 (?), 3.
C. virilis. 2, 2, 3 (?).

95. *Neosho or Grand River.*
C. gracilis. 15, 1 (?); 24, ? 2.
C. nais. 15, 1 (?), 2 (?).
C. neglectus. 24, 5, 6.
C. setosus. 24, 1.
C. virilis. 13, 1; 15, 21; 24, 6, 7, ? 9.

96. *Verdigris River.*
C. gracilis. 15, 1 (?).
C. nais. 15, 1 (?), 2 (?).

97. *Salt Fork Arkansas River.*
C. simulans. 15, 2, 4, 6.
C. virilis. 15, 12, 19.

98. WHITE RIVER.
C. blandingii acutus. 2, 1.
C. diogenes. 2, 1 (?).
C. longidigitus. 2, 1.
C. meeki. 2, 2 (?).
C. neglectus. 2, 1, 2 (?), 4; 24, 2, 3, 4.
C. rusticus. 2, 1; 24, 2, 3 (?), 5.
C. setosus. 24, ? 2.
C. virilis. 2, 1, 3 (?).

89. MISSISSIPPI RIVER—*continued:*

98. WHITE RIVER.

99. *Black River.*

C. blandingii acutus. 2, 2.
C. hylas. 24, 1.
C. palmeri. 2, 2.
C. rusticus. 2, 2.
C. virilis. 24, 5.

100. ST. FRANCIS RIVER.

C. diogenes. 2, 2.
C. lancifer. 2, 1.
C. palmeri. 2, 1, 3.

101. OHIO RIVER.

C. argillicola. 12, 4.
C. bartonii. 12, 3; 16, 2; 34, 1, 2, 3, 5; 37, 1, 12 (?); 47, 3.
C. carolinus. 37, 1 (?).
C. diogenes. 16, ? 1; 37, 2 (?).
C. propinquus. 37, 1 (?).
C. propinquus sanbornii. 16, 1.
C. putnami. 12, ? 1.
C. rusticus. 12, 3; 16, 3; 34, 4; 37, 1, 3.
C. sloanii. 12, 1, 2, 3.

102. *Tennessee River.*

C. alabamensis. 1, 1.
C. bartonii. 32, 1, 3 (?); 41, 1, 3, 5, 6.
C. blandingii acutus. 1, 4, 5.
C. carolinus. 45, 1.
C. compressus. 1, 1.
C. erichsonianus. 41, 2, 3.
C. extraneus. 41, 1.
C. extraneus girardianus. 1, 1; 41, 1.
C. forceps. 1, 1; 41, 1.
C. immunis. 1, 1.
C. latimanus. 1, 2, 3 (?).
C. longulus. 32, 1; 41, 2.
C. putnami. 41, ? 1.
C. rusticus. 1, 1.
C. spinosus. 1, 1, 2; 41, 3.
C. virilis. 1, 1; 41, ? 1.

103. Clinch River.

C. bartonii. 16, 1; 41, 4.
C. bartonii longirostis. 41, 1; 47, 1.
C. carolinus. 41, 1.
C. forceps. 41, 2, 3.
C. longulus. 41, 3, 5.
C. putnami. 16, 1.
C. rusticus. 41, 2.
C. spinosus. 41, 1, 2.

104. Holston River.

C. bartonii. 32, 6 (?); 41, 2; 45, 3, 4.
C. bartonii longirostris. 41, 2.
C. forceps. 45, 1.
C. longulus. 41, 1; 45, 5.

89. MISSISSIPPI RIVER—*continued:*

101. OHIO RIVER.

102. *Tennessee River.*

105. French Broad River.

C. acuminatus. 32, 2 (?), 5.
C. bartonii. 32, 2.
C. erichsonianus. 41, 1.
C. longulus. 41, 4.

106. Cumberland River.

C. bartonii. 16, 7.
C. latimanus. 41, 1.
C. rusticus. 41, 1, 3.

107. Wabash River.

C. argillicola. 11, 1.
C. blandingii acutus. 11, 9; 12, 1, 2 (?), 3(?), 6.
C. diogenes. 12, 1 (?), 3, 8.
C. gracilis. 11, 4.
C. immunis. 12, 4 (?), 5, 7, 8.
C. immunis spinirostris. 12, 1.
C. propinquus. 12, 2, 6 (?), 7, 8, 9.
C. rusticus. 12, 5.
C. virilis. 12, 5 (?), 6 (?).

108. Patoka River.

C. indianensis. 12, 1, 2.

109. White River.

C. argillicola. 12, 1, 2, 3.
C. bartonii. 12, 1, 2, 4, 5.
C. blandingii acutus. 12, 2 (?).
C. diogenes. 12, 2, 4, 5, 6.
C. immunis. 12, 1, 2, 3.
C. propinquus. 12, 3, 10, 11, 13, 14.
C. putnami. 12, ?3.
C. rusticus. 12, 1, 2, 4.

110. Green River.

C. bartonii. 16, 5, 6.
C. cornutus. 16, 1.
C. diogenes. 16, ?2.
C. putnami. 16, 2, 3.

111. Kentucky River.

C. bartonii. 16, 3.
C. rusticus. 16, 1, 2.

112. White Water River.

C. propinquus. 12, 12.
C. putnami. 12, 2.
C. rusticus. 12, 6.

113. Miami River.

C. diogenes. 34, 2.
C. gracilis. 34, 1.
C. rusticus. 34, 23.

114. Scioto River.

C. bartonii. 34, 4.
C. diogenes. 34, 1.

89. MISSISSIPPI RIVER—*continued:*

101. OHIO RIVER.

102. *Tennessee River.*

115. Great Kanawha River.

C. bartonii. 32, 6 (?); 45, 1; 47, 2.
C. bartonii robustus. 45, 2.
C. longulus. 45, 4; 47, ? 1.

116. Alleghany River.

C. bartonii. 37, 10, 11, 12 (?).
C. bartonii robustus. 37, 1.
C. carolinus. 37, 11 (?).
C. diogenes. 37, 1, 2 (?).
C. obscurus. 37, 1 (?).
C. propinquus. 37, 1.

117. Monongahela River.

C. bartonii. 37, 12 (?).
C. carolinus. 37, 1 (?); 47, 1.
C. propinquus. 37, 1.

118. Youghioughany River.

C. bartonii. 19, 2.
C. diogenes. 19, 6.
C. obscurus. 37, 1 (?).

119. MERAMEC RIVER.

C. harrisonii. 24, 1.
C. medius. 24, 1.
C. rusticus. 24, 4.
C. virilis. 24, 3.

120. MISSOURI RIVER.

C. diogenes. 15, 1; 24, 2.
C. immunis. 14, 4, 5; 15, 2; 26, 2.
C. virilis. 14, 5, 13; 15, 5, 20; 24, 4, 8; 26, 1, 2.

121. *Osage River.*

C. bartonii. 24, ? 1.
C. neglectus. 24, 1.
C. rusticus. 15, 1; 24, 1, 3, ? 5.
C. virilis. 15, 10; 24, 2.

122. *Kansas River.*

C. diogenes. 15, 2.
C. gracilis. 15, 2.
C. immunis. 15, 3, 4.
C. immunis spinirostris. 15, 1, 2.
C. neglectus. 15, 1, 4.
C. virilis. 15, 1, 2, 3, 6, 11, 13, 14, 15, 16, 17, 18, 22, 25, 26.

123. Republican River.

C. neglectus. 15, 2, 3, ? 5.
C. virilis. 15, 7, 9, ? 27.

124. Solomon River.

C. pilosus. 15, 1.

125. Smoky Hill River.

C. immunis. 15, 1.
C. simulans. 15, 1.
C. virilis. 15, 8.

89. MISSISSIPPI RIVER—*continued:*
120. MISSOURI RIVER.
122. *Kansas River.*
126. Saline River.
C. pilosus. 15, ? 2.
C. virilis. 15, 23, 24.
127. *Platte River.*
C. immunis. 26, 1.
128. South Platte River.
C. diogenes. 5, 2; 49, 1.
129. North Platte River.
C. immunis. 49, 1.
C. virilis. 49, 1.
130. *Little Sioux River.*
C. virilis. 14, 7, 10.
131. ILLINOIS RIVER.
C. blandingii acutus. 11, 1, 2, 3, 4, 6, 7.
C. diogenes. 11, 1, 4, 5.
C. gracilis. 11, 1, 3, 5 (?); 48, 1 (?).
C. immunis. 11, 34.
C. propinquus. 11, 3, 4, 5, 6.
C. rusticus. 11, 1.
C. troglodytes. 11, ? 1.
C. virilis. 11, 1, 3, 4, 5.
132. *Sangamon River.*
C. bartonii robustus. 11, 1.
C. gracilis. 11, 2.
C. virilis. 11, 2.
133. *Fox River.*
C. diogenes. 48, 2.
C. rusticus. 48, 4.
C. virilis. 48, 1.
134. *Kankakee River.*
C. blandingii acutus. 12, 4 (?), 5.
C. diogenes. 12, 7.
C. immunis. 12, 6.
C. propinquus. 12, 5.
C. virilis. 12, 7.
135. DES MOINES RIVER.
C. immunis. 14, 2.
C. propinquus. 14, 1.
C. rusticus. 14, 1.
C. virilis. 14, 3, 4, 8, 9.
136. IOWA RIVER.
C. blandingii acutus. 14, 1.
C. diogenes. 14, 2.
C. immunis. 14, 1, 6.
C. virilis. 14, 14.
137. *Cedar River.*
C. immunis. 14, 3.
C. rusticus. 14, 2, 3.
C. virilis. 14, 15.

89. MISSISSIPPI RIVER—*continued:*

138. ROCK RIVER.

C. diogenes. 48, 1.
C. propinquus. 11, 1, 2; 48, 1, 2.
C. virilis. 11, 8; 48, 4, 5, 6.

139. WAPSIPINICON RIVER.

C. virilis. 14, 6.

140. MOQUAKITA RIVER.

C. diogenes. 14, 3.
C. virilis. 14, 12.

141. TURKEY RIVER.

C. neglectus. 14, 1.

142. RED RIVER OF THE NORTH AND MINNESOTA RIVER.

C. diogenes. 22, 1.
C. virilis. C., 3; 33, 1.

143. *Souris or Mouse River.*

C. virilis. 33, 2.

144. WISCONSIN RIVER.

C. blandingii acutus. 48, 2.
C. rusticus. 48, 3.
C. virilis. 48, 2, 3.

145. TRINITY RIVER.

C. blandingii. 42, ? 1.
C. simulans. 42, 1.

146. CLEAR CREEK.

C. clarkii. 42, 1.

147. BRAZOS RIVER.

C. argillicola. 42, 2.

148. GUADALUPE RIVER.

C. argillicola. 42, 1.
C. clarkii. 42, 2.

149. RIO GRANDE RIVER.

C. clarkii. 42, 4.

150. PECOS RIVER.

C. simulans. 30, 1, 2, 3.

LOCALITIES NOT TABULATED.

C. acherontis, 8, 1, 2.
C. advena, 9, 1.
C. angustatus, 9, 1.
C. barbatus, 9, 1; 23, ? 1.
C. bartonii, 9, ? 1; 16, 4; 47, 5.
C. bartonii robustus, 41, ? 1.
C. blandingii, 23, 1; 31, 1; 32, 5.
C. carinatus, M., 1, 2, 3.
C. chaplanus, M., 1.
C. clarkii, 34, ? 1; 42, 3.
C. cubensis, Cuba, 1, 2.

C. digueti, M., 1.
C. diogenes, 5, 1; 41 ? 1.
C. gracilis, 12, ? 1.
C. hamulatus, 41, 1.
C. immunis, M., 1; 11, 5.
C. lancifer, 23, 1.
C. maniculatus, 9, 1.
C. mexicanus, M., 1, 2, ? 3, ? 4.
C. mississippiensis, 23, 1.
C. montezumæ, M., 1, 2, 3, 4, 5.
C. montezumæ areolatus, M., 1.
C. montezumæ dugesii, M., 1.
C. montezumæ occidentalis, M., 1.
C. nebrascensis, 26, 1.
C. pellucidus.
C. pellucidus testii.
C. propinquus, 11, 7; 12, 1.
C. rusticus, 21, 2; 42, 1.
C. sloanii, 16, 1.
C. troglodytes, 9, 1.
C. typhlobius.
C. virilis, 12, 2; 21, 1; 22, 4.
C. wiegmanni, M., 1.

DISTRIBUTION BY STATES.

Space need not be devoted to a table of species with the states in which they occur, since that information may be obtained from the systematically arranged list of species of the genus given in the introduction, but for convenience in studying distribution, a list of states, with the species occurring therein, is given.

Canada.

C. argillicola.
C. bartonii.
C. bartonii robustus.
C. propinquus.
C. virilis.

United States.

ALABAMA.

C. barbatus.
C. bartonii longirostris.
C. blandingii acutus.
C. clarkii.
C. compressus.
C. erichsonianus.
C. evermanni.
C. extraneus.
C. extraneus girardianus.
C. forceps.
C. immunis.
C. latimanus.
C. lecontei.
C. rusticus.
C. spinosus.
C. versutus.
C. virilis.

ARKANSAS.

C. blandingii acutus.
C. difficilis.
C. diogenes.
C. lancifer.
C. longidigitus.
C. meeki.
C. neglectus.
C. palmeri.
C. rusticus.
C. virilis.

COLORADO.

C. diogenes.

DISTRICT OF COLUMBIA.

C. affinis.
C. bartonii.
C. diogenes.

FLORIDA.

C. acherontis.
C. alleni.
C. clarkii.
C. fallax.
C. versutus.

GEORGIA.

C. advena.
C. angustatus.
C. barbatus.
C. bartonii.
C. blandingii.
C. extraneus.
C. jordani.
C. latimanus.
C. lecontei.
C. maniculatus.
C. pubescens.
C. spiculifer.
C. spinosus.
C. troglodytes.

ILLINOIS.

C. argillicola.
C. bartonii robustus.
C. blandingii acutus.
C. diogenes.
C. gracilis.
C. immunis.
C. propinquus.
C. rusticus.
C. troglodytes.
C. virilis.

INDIANA.

C. argillicola.
C. bartonii.
C. blandingii acutus.
C. diogenes.
C. gracilis.
C. immunis.
C. immunis spinirostris.
C. pellucidus.
C. pellucidus testii.
C. propinquus.
C. putnami.
C. rusticus.
C. sloanii.
C. virilis.

INDIAN TERRITORY.

C. blandingii acutus.
C. carolinus.
C. difficilis.
C. palmeri longimanus.
C. virilis.

IOWA.

C. blandingii acutus.
C. diogenes.
C. gracilis.
C. immunis.
C. neglectus.
C. propinquus.
C. rusticus.
C. virilis.

KANSAS.

C. diogenes.
C. gracilis.
C. immunis.
C. immunis spinirostris.
C. nais.
C. neglectus.
C. pilosus.
C. rusticus.
C. simulans.
C. virilis.

KENTUCKY.

C. bartonii.
C. cornutus.
C. diogenes.
C. pellucidus.
C. propinquus.
C. putnami.
C. rusticus.
C. sloanii.

LOUISIANA.

C. argillicola.
C. blandingii acutus.
C. clarkii.
C. diogenes.
C. schufeldtii.

MAINE.

C. bartonii.

MARYLAND.

C. affinis.
C. bartonii.
C. bartonii robustus.
C. blandingii.
C. diogenes.
C. uhleri.

MASSACHUSETTS.

C. bartonii.

MICHIGAN.

C. argillicola.
C. diogenes.
C. immunis.
C. propinquus.
C. rusticus.
C. virilis.

MINNESOTA.

C. diogenes.
C. immunis.
C. virilis.

MISSISSIPPI.

C. argillicola.
C. babatus.
C. blandingii.
C. clarkii.
C. clypeatus.
C. diogenes.
C. hayi.
C. lancifer.
C. latimanus.
C. mississippiensis.

MISSOURI.

C. bartonii.
C. blandingii acutus.
C. diogenes.
C. gracilis.
C. harrisonii.
C. hylas.
C. immunis.
C. medius.
C. neglectus.
C. rusticus.
C. setosus.
C. virilis.

NEBRASKA.

C. immunis.
C. nebrascensis.
C. virilis.

NEW JERSEY.

C. affinis.
C. bartonii.
C. blandingii.
C. diogenes.

NEW MEXICO.

C. simulans.

NEW YORK.

C. affinis.
C. bartonii.
C. bartonii robustus.
C. blandingii.
C. immunis.
C. obscurus.
C. propinquus.
C. virilis.

NORTH CAROLINA.

C. acuminatus.
C. argillicola.
C. bartonii.
C. blandingii.
C. blandingii acutus.
C. carolinus.
C. diogenes.
C. longulus.
C. spinosus.

OHIO.

C. argillicola.
C. bartonii.
C. blandingii acutus.
C. clarkii.
C. diogenes.
C. gracilis.
C. immunis.
C. propinquus.
C. propinquus sanbornii.
C. rusticus.

PENNSYLVANIA.

C. affinis.
C. bartonii.
C. bartonii robustus.
C. carolinus.
C. diogenes.
C. obscurus.
C. propinquus.
C. rusticus.

RHODE ISLAND.

C. bartonii.

SOUTH CAROLINA.

C. acuminatus.
C. barbatus.
C. bartonii.
C. blandingii.
C. blandingii acutus.
C. hagenianus.
C. latimanus.
C. spinosus.
C. troglodytes.

TENNESSEE.

C. bartonii.
C. bartonii longirostris.
C. bartonii robustus.
C. blandingii acutus.
C. carolinus.
C. diogenes.
C. erichsonianus.
C. extraneus.
C. extraneus girardianus.
C. forceps.
C. hamulatus.
C. immunis spinirostris.
C. latimanus.
C. longulus.
C. palmeri.
C. putnami.
C. rusticus.
C. spinosus.
C. virilis.

TEXAS.

C. argillicola.
C. blandingii.
C. blandingii acutus.
C. clarkii.
C. neglectus.
C. palmeri longimanus.
C. rusticus.
C. simulans.
C. virilis.

VERMONT.

C. bartonii.

VIRGINIA.

C. affinis.
C. bartonii.
C. bartonii robustus.
C. blandingii.
C. carolinus.
C. diogenes.
C. forceps.
C. longulus.

WEST VIRGINIA.

C. bartonii.
C. bartonii longirostris.
C. carolinus.
C. longulus.

WISCONSIN.

C. blandingii acutus.
C. diogenes.
C. gracilis.
C. immunis.
C. propinquus.
C. rusticus.
C. stygius.
C. virilis.

WYOMING.

C. diogenes.
C. immunis.
C. virilis.

Mexico.

C. carinatus.
C. chaplanus.
C. digueti.
C. immunis.
C. mexicanus.
C. montezumæ.
C. montezumæ areolatus.
C. montezumæ dugesii.
C. montezumæ occidentalis.
C. wiegmanni.

Cuba.

C. cubensis.

CONCLUSIONS CONCERNING DISTRIBUTION.

While working over the data for the catalogue, I sometimes thought that it might be possible to prepare a list of species which occur in mountain streams, or in the lowlands, but I have been convinced of the wisdom of my intention to make the paper mainly a compilation of data, with very few conclusions. While many minor conclusions have occurred to me, they will not be suggested without more extensive data. In considering the distribution of individuals and species with

reference to local factors, as temperature, purity and rapidity of stream, direct and detailed observations are very scanty, while conclusions as to distribution in the broader sense, the range of species, groups, and the genus itself, are limited by the unexplored condition of much of the territory.

On the subject of distribution of the crayfishes in its ecological phases, very little has appeared. Faxon ('85) observes the occurrence of the same species in the head waters of streams on the opposite side of a watershed, as has been observed in fishes, and gives as examples *C. extraneus* and *C. spinosus* in the upper waters of the Santee, Alabama and Tennessee rivers, and also that the forms of the upper and lower part of a river may be different. As illustrations of this, he gives *C. bartonii*, *C. latimanus*, *C. acuminatus* and *C. spinosus* in the upper portion of the Santee river, while in the lower portion of the same basin live *C. blandingii acutus* and *C. troglodytes*. Various minor notes have appeared upon the occurrence of different species in different types of localities, but these are for the most part too meager to be considered in a very general summary. The observations will be found under the species concerned. Ganong ('87 and '89) has discussed the distribution of *C. bartonii*, the only species found in New Brunswick. After giving the localities (see catalogue), he says: "The crayfish has probably been introduced into this province by way of the Allegash from the head waters of the Penobscot. 'The St. John and Penobscot are connected by a canal from Telos lake to Webster pond, and the divide between the head waters of the Penobscot and the Kennebec is so low that it is said that in very wet seasons their waters intermingle.' It has probably spread into the Restigouche by way of Grand river, and into the Miramichi by way either of the Nashwaak or of the Shiktehawk or Beccaguimec. Where the sources of these streams are so near each other, and interlock in such a fashion as they do, there would be little difficulty in the animal spreading from one to the other, particularly where the divide is low."

A case of direct observation upon the relative distribution of different species is given by Williamson ('01), who says, under *C. bartonii robustus:* "Observations indicate that this variety occurs in streams in which both *bartonii* and *propinquus* occur, the variety being found in that part of the stream where the

two species are found. A collector starting at the head waters of Squaw Run [37, 1] would find *bartonii;* following the stream, he would soon notice *robustus* among his captures; then an occasional *propinquus*, till finally *bartonii* would become more rare and disappear, and near the mouth of the creek he would find only the species *propinquus.* If the collector chose to follow on down the Alleghany river he would still notice only *propinquus.* After reaching the Ohio, a few specimens from the ripples about Neville island would show him that he had found another species, *rusticus.*"

Under the "Summary of Habits" reference was made to the "Conclusions Concerning Distribution" for a discussion of character of localities. Crayfishes are found in varied habitats, from burrows in a prairie which is dry for a large part of the year, stagnant ponds, roadside ditches, and salt marshes, to the pure cold water of mountain springs and streams. The differences between the stream which has reached or nearly reached base level and one which is in a younger stage of its life-history, or between the upper and lower portions of a stream which shows many stages of an ideal life-history, are well known and need not be described here. Certain fishes are known to be typical of each class of locality, and it is safe to assume that the rule will to some extent hold good with the crayfishes as well. For some species it is already known and field observation will doubtless show it to be true of others. It is not advisable to attempt a list of forms at present, but much may be learned in regard to any species by consulting the table of distribution by states and especially by river systems.

One cannot work in the limited literature on the habits and distribution of the different forms without observing that the same species may be recorded as occurring in, or even typical of, very different conditions of environment. As I have pointed out, *C. virilis* is found in small streams, occurring almost exclusively in the rocky, more rapid portions, and being absent in the muddier, slower portions, though it may be found in very muddy streams or even in stagnant ponds with *C. immunis* and *C. gracilis*, where it must have the same habits. *C. bartonii* seems to be characteristic of the cooler, purer mountain springs and streams and is found in caves with *C. pellucidus*, but it is also found associated with *C. diogenes*, and with the same

habits. *C. affinis* has been shown to occur in very different habitats. *C. blandingii* is by no means confined to one type of locality. The species given are sufficient to illustrate the point in question.

The distribution of the fresh-water fishes has been quite carefully worked up, and they have been in a limited way divided into classes according to the character of the habitat.[24] At the present time it is not advisable to attempt to assign the crayfishes to groups in any but a provisional manner, but the available data for any species may be obtained from the tables of distribution and the catalogue. Certain species it is possible to limit quite definitely to some type of locality.

Of species occurring in salt water only one is known: *C. uhleri* is found in salt marshes and also in brackish and fresh water, where *C. blandingii* is sometimes found associated with it. According to Faxon ('85), Lake Tezcoco, where *C. montezumæ* is found, is said to be salt.

The burrowing species obviously have a great advantage over the other forms in distribution, in that they are able to occupy territory which is not available for others except at certain seasons. I may here call attention to their great range of distribution. *C. diogenes* is the most widely distributed species of the genus, occurring in Boulder county, Colorado, at the foot of the Rocky Mountains and southeastern Wyoming on the west, in Minnesota, Wisconsin and Michigan on the north, in New Jersey, Maryland, Virginia, North and South Carolina on the east, and in Mississippi and southern Louisiana on the south. *C. argillicola* is found in Canada on Lake Ontario, in Michigan, Ohio, Illinois, Indiana, North Carolina, Mississippi, Louisiana, and Texas. *C. carolinus*, long known from only the Appalachian region of Virginia, is now known to occur in northeastern Indian Territory and western Pennsylvania. In how far this distribution is to be explained by the habits of the ani-

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24. Jordan (Science Sketches) recognizes the following classes of fresh-water fishes:

1. Lowland fishes.
2. Channel fishes.
3. Upland fishes.
4. Mountain fishes.
5. Lake fishes.
6. Anadromous fishes.
7. Catadromous fishes.
8. Brackish-water fishes.

With the sixth and seventh we have nothing to do in the crayfishes. The fifth group is hardly represented, or at least there are as yet very little data to indicate reasons for such a group as Jordan has defined it. Several species have been reported from lakes, but whether from the lake itself or from small tributaries or bays is not known in many cases. *C. stygius* is reported as washed up on the shores of Lake Michigan during a storm. With the first four and the eighth group we may be concerned, but it is impossible at the present time to give a list assigning more than a few of the species to a definite type of locality.

mals it is hardly safe to suggest.[25] Range in altitude as well as in longitude and latitude is to be noticed. Compare the elevation of Boulder, Colo., with lower Louisiana.

The swamp, stagnant-water and lowland species are many, and it is from these that burrowing species may for the most part be supposed to have originated. Without attempting to present a list, attention may be called to the forms found along the Atlantic coast plain and the lower parts of the Gulf States—Florida, Georgia, Alabama, Mississippi, Louisiana, and lower Texas. It is very evident, however, that height above the sea is not the only factor determining lowland conditions, and an examination of the streams and species of the Mississippi valley gives some interesting suggestions.

Data are entirely too meager to say what forms are characteristic of the larger streams. In most of the material reported, data which would make it of value for any such work as this are absent, and very little can be safely concluded from the general locations given. The small tributaries of a stream may be entirely different from the main stream and the species found in them quite different. Until adequate data are secured by collectors and published with catalogues of species little is to be hoped for.

Some species seem to be characteristic of mountain streams, and a comparison of the fauna of the upper Appalachian tributaries of some of the Atlantic and Gulf rivers offers suggestions of interest. *C. extraneus*, *C. spinosus*, *C. bartonii*, *C. acuminatus*, *C. erichsonianus*, *C. forceps*, *C. longulus*, and perhaps several others, seem to be confined to mountain streams.

That the number of species bears no relation to the area drained by the river is well known, and may be illustrated by the following table:

Penobscot, 9000 miles, one species.[26]
Hudson, 13,400 miles, two species.
Potomac, 14,500 miles, seven species.
Cape Fear, 8,400 miles, three species.
Santee, 14,700 miles, six species.
Tennessee, 43,900 miles, twenty-one species.

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25. The burrowing species are not so easily collected as are some of the others, and our knowledge of their actual distribution is very imperfect.

26. In comparing the number of species found in different streams or states I have counted varieties as species.

Ohio, 201,700 miles, twenty-seven species.

Arkansas, 185,700 miles, twelve species.

Faxon ('85) says: "The distinction between the species of the upper waters and the lower waters is most marked in rivers that have a heavy fall from their source to their mouth." I have found it interesting to compare the number of species in a stream with its profile. The Mississippi river, exclusive of its tributaries, has a fall of 1462 feet in 2296 miles, and has thirteen species. The Tennessee river, including its principal tributaries, has a fall of 5214 feet in less than half the number of miles, and contains twenty-one species. The Wabash river, in a length of 517 miles, has a fall of 689 feet, and yields twelve species. Of the streams emptying on the south Atlantic coast, the Cape Fear river, with a fall of 130 feet in 172 miles, has three species; the Santee, with its tributaries, a fall of 2658 feet in 479 miles, and six species; the Savannah river, with a length of 314 miles and a fall of 577 feet, three species. Comparing the distribution by states, we find that in the southern United States, where differentiation into species is the greatest, Florida, with a maximum elevation of 328 feet, has five species; Louisiana, reaching a height of 362 feet, has five; Mississippi, 602 feet, has ten; Georgia, ranging from sea-level to over 5000 feet, has fourteen; Alabama, sea-level to 2018 feet, has seventeen species; and Texas, sea-level to nearly 8000 feet, has ten species. The range of elevation can give no idea of the profile of a stream or a state, and the reasons for the differences may be much more clearly seen by a glance at a curve plotting the elevation of the stream at different points. In the examples given a profile will show that there is a very great difference in the amount and relative proportion of the mountain, upland and flood-plain portion of the river in each case. Theoretically, other things being equal, the stream offering the most diverse conditions of environment would be expected to have the greatest number of species, and it is evident that even in a river of considerable length a stream with but a small fall can offer comparatively few conditions, while a stream with a heavy fall during the first part of its course may offer a great number. It is very easy to select from the tables illustrations which do not agree with those here given, and I am perfectly aware that the problem is by no means simple or without complications, but

I think that when proper allowance is made for other factors the suggestion made here of a direct relation between the contour of a stream and the number of its species is a helpful one.

The occurrence of the same species in the head waters of streams on the opposite sides of a watershed has already been referred to. Adams ('01) calls attention to the occurrence of *C. spinosus*, *C. erichsonianus* and *C. extraneus* in the Tennessee river, and also in the head waters of the Coosa-Alabama system, and calls attention to its significance. The occurrence of *C. carolinus*, apparently an upland species, in northeastern Indian Territory, has been noted.[27] Many cases of apparent isolation are doubtless due to our imperfect knowledge of distribution. In several cases I have found instances in which upland species occurred in the lower portion of the stream under conditions which would seem to be quite different from their usual ones. Whether these isolated localities are merely the edge of the range of the species which is to be found under very diverse conditions, or whether its occurrence there is accidental, remains to be seen.

Distribution in its broader sense I shall not consider. Faxon ('85) and Ortmann ('02) have discussed the distribution of the groups and the genus, and have advanced theories for the origin of the genus and its groups. Their theories are somewhat at variance with each other, but space cannot be devoted to a discussion of them here. My object has been to consider the ecological factors, and while some interesting points present themselves in connection with the groups the time is not ripe for their discussion.

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27. In this place a statement made by Jordan (Science Sketches) is interesting: "Again, streams of the Ozark mountains, similar in character to the rivers of East Tennessee, have an essentially similar fish fauna, although between the Ozarks and the Cumberland range lies an area of lowland bayous into which such fishes are never known to penetrate. We can, however, imagine that these upland fishes may be sometimes swept down from one side or the other into the Mississippi, from which they might ascend on the other side. But such transfers certainly do not often happen. This is apparent from the fact that the two faunæ are not quite identical, and in some cases the same species are represented by perceptibly different varieties on one side and the other. The time of the commingling of these faunæ is perhaps now past, and it may have occurred only when the character of the intervening region was colder than it is at present."

SUMMARY AND CONCLUSIONS CONCERNING HABITS.

CHARACTER OF LOCALITIES. The character of the waters in which the crayfishes occur has been sufficiently discussed under the conclusions concerning distribution.

SUMMARY OF HABITS BY GROUPS. As already suggested under "Distribution," the time is not come for any generalizations as to the habits of the groups. The most-modified forms —the blind species and the burrowing species—are not confined to a single group.

HABITS DURING WINTER. Of the habits of the crayfishes during the winter little is definitely recorded. It seems most probable that the stream-inhabiting species pass the winter in burrows in the bank or under stones, etc., in the bed of the streams. The latter is sometimes the case with *C. virilis*. The burrowing species seem quite generally to spend the winter in burrows, coming out early in the spring, and returning again when the water begins to become low, as the summer progresses.

THE BLIND SPECIES. A summary is unnecessary; the information at hand may be found under *C. acherontis*, *C. setosus*, *C. hamulatus*, *C. pellucidus*, and *C. pellucidus testii*.

THE BURROWING SPECIES. Some of the North American forms have attracted particular attention on account of a peculiarity in their mode of life as compared with the better-known European species. While the interest which has been taken in the burrowing forms is a perfectly natural one, it seems that in some ways an entirely too difficult problem has been made of it, for the origin of the habit seems quite easy of explanation. *Cambarus* is not the only genus of the family having representatives which depend more or less upon this mode of life, at least at certain seasons of the year, or when being in certain localities,[28] and the ultimate adoption of this method of life as the regular one by some species is not at all difficult to conceive, especially in a territory vast areas of which are habitable for the typical members of the genus for a part of the year only.

28. The burrowing habits of *Cheraps bicarinatus* have been described, and the same habit is characteristic of some members of the South American genus *Parastacus*. (See Faxon, '98, and Lonnberg, '98.) In some localities *Astacus* is said to burrow extensively in the banks of the streams. (See Huxley, '97.)

Under this head are to be placed only the species which show a more special dependence upon this method of life for their ability to live in a given territory. It seems not unreasonable to suppose that most, if not all, the stream-inhabiting species dig short burrows into the banks more or less frequently, at least in certain localities.

The following species are those which seem to be most dependent on the burrowing habit: *C. diogenes*, *C. gracilis*, *C. carolinus*, *C. argillicola*, *C. simulans*, and *C. immunis*.

C. diogenes has well been characterized as preeminently a burrowing species, and, owing to its range of distribution and peculiarities of its habits as compared with other species inhabiting the same localities, more observations have been made on this than any other form. Its presence is usually indicated in the low places, where it is most frequently found by the large number of mud "chimneys," sometimes scattered over many acres, about a foot in height, radiating from some sluggish stream, ditch, brook, or lower, moister portion of the area, the animals being often found at a considerable distance from any permanent body of water. Of the other species, *C. gracilis* seems to be as typically a burrowing species as *C. diogenes*, being generally reported as an inhabitant of prairie regions. Adults are to be found in stagnant ponds only in early spring, only one exception being noted. While the burrows are frequently found a long distance from any permanent water, *C. simulans* has been reported from streams and ponds and from burrows in a slough. *C. immunis* is recorded mostly from stagnant ponds, resorting to burrowing upon the drying up of these. I have never taken it in running streams. For *C. argillicola* and *C. carolinus* the character of the habitat has not been described.

The chimney of *C. diogenes* has a maximum height of one foot, but is usually lower, is circularly pyramidal in shape, often somewhat higher than broad, the most remarkable difference being that of chimneys two inches in diameter and eight to eleven inches in height observed on the sloping side of a ditch, by Abbott, who states that those found in meadows at a distance from running water were invariably broader at the base and not so high as those located near running water. Tarr records exceptional cases where the burrows were in

gravelly ground and the chimneys were, naturally, of the same material, instead of clay, as is usually the case. The description of the exterior of the chimney, composed of irregularly arranged nodules of clay, and the inside a smooth opening of the same diameter as the burrow, is much the same in all the papers. Of the external form of the chimneys of other burrowing species little has been written, but so far as essentials of construction and general appearance are concerned they may be assumed to be very similar.

It would be useless to go into a detailed enumeration of the different forms of burrows described, since, until by more extensive observations than have yet been made the contrary is shown to be the case, the amount of regularity, beyond the necessary similarity of form which characterizes the simple burrows, may not be supposed to be very great. It seems quite evident that the burrows are made as the level of the water lowers, those near the edge having a depth of but a few inches, while those farther back may be some feet deep. A cistern-shaped opening, containing water, is described at the bottom, while enlargements at various intervals in the burrows have been noted and probably correctly explained as the original termini of the burrow which has been projected deeper upon the lowering of the water in the soil, but in the case of the burrows of *C. carolinus*, as observed by Williamson, this interpretation does not seem to hold, and may not in all cases with *C. diogenes* or the other forms. The burrows have usually been described as separate, but when they are very close together they are not unlikely to become connected. The presence of more than one opening to the same burrow in many cases seems established. Sometimes one and sometimes two individuals are found in a burrow.

The purpose and method of construction of the "chimney," as it has been aptly called, have called forth considerable discussion, some maintaining that a structure of such regularity of construction must have some purpose; others concluding that the building of a chimney simply represents the safest and most convenient method of disposing of the material obtained in excavating the burrow. The latter view seems to have by far the greater amount of evidence in its favor. The purpose of sealing the burrows needs more study. The method by

which it is accomplished seems to be simply the filling in of the opening, necessarily kept till the last, through the chimney, with material brought from below. That it is brought from below, and that the sealing is not merely the result of an accidental contraction of the upper part of the chimney when in a moist condition, is shown by the fact that in the case of some chimneys (of *C. diogenes?*) examined the opening was filled with clay of a different color from that of the surface soil or that composing the remainder of the chimney. The process of building the chimney has been described from actual observation only once—by Abbott.

Concerning the purpose of the burrowing there can now be no question, enabling the animal, as it does, to occupy territory otherwise uninhabitable. Some species of the genus appear never to resort to the habit in its limited interpretation, while others, *C. immunis*, and to a less extent *C. virilis*, for example, are inhabitants of ponds or streams and resort to burrowing upon the drying up of the pond or the approach of winter, while *C. diogenes* and *C. gracilis* have adopted this mode of life almost entirely, being found in the open water during but a very small part of the year. That the burrows are not for retreats while the eggs are being hatched has been clearly shown. That they serve as a place of protection against enemies has been suggested. While this cannot be the primary purpose for which they are formed, it may be that the burrowing species suffer less from animal enemies than do some others. My impression is that the percentage of mutilation in *C. gracilis* is less than in *C. immunis* or *C. virilis*, which do not spend so much time in burrows. Burrows are almost invariably described as extending to the water in the soil,[29] and while the water is often very muddy, it enables the animal to keep its gills moist, and this seems to be all that is necessary. There are observations to indicate that in the burrows the animals do not spend all the time in the water at the bottom, but are apt to be found above it.[30] The securing of food is a question which has not been

29. I am told that travelers on the plains watch for the crayfish chimneys as the best indication of a suitable locality in which to dig for water.

30. It is by no means necessary for the crayfish to spend all the time in water. Some of the burrowing species have sometimes been reported as making long excursions overland. *C. blandingii* was taken in a log at a considerable distance from water. *Astacus* is said to make short excursions inland sometimes. I have never been so fortunate as to observe crayfishes climbing trees to escape the rising water, as they were reported by Mr. Holder as doing!

Of *Parastacus hasslerí*, Lonnberg ('98) says: "The sides of the carapace covering the branchial chambers are beset with numerous setæ, each implanted at the anterior margin of a

satisfactorily solved; but the observations have indicated that the species are nocturnal in their habits, and in some cases may leave the burrows and forage for food, or wait at the mouth for anything that may come within reach. That the animals may live for long periods with but little food is known.

In addition to the above-mentioned species, besides the burrowing in the banks or bed of the streams, as has been noted for *C. bartonii*, *C. propinquus*, and *C. sloanii*, there are doubtless others which burrow extensively when conditions demand it. Lonnberg sometimes found *C. fallax* and *C. alleni* "digging holes on the shore at low water." Schufeldt figures the chimney of *C. bartonii robustus*; *C. virilis* is reported almost exclusively from streams and lakes, but has sometimes been found with *C. immunis*, almost exclusively a stagnant-pond species, and when in such localities it must burrow, as do forms characteristic of such localities. Faxon reports *C. blandingii* from Texas with the label name of "burrowing crab," a fact which is suggestive at least.

From the data now at hand, it certainly seems safe to conclude that the burrowing habit has been adopted as a means of living through an unfavorable period, and that in some species this method of life has been adopted as the almost exclusive one, while all the other advantages of this habit of life, if there are any, are entirely secondary.[31] The burrowing species are to be regarded as the most specialized of the genus.

EXUVIATION. On the process itself nothing of particular value has appeared, and even if observations were complete,

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granule, and between these granules a large number of tiny grooves are seen. The posterior margin of the cervical groove is armed with a dense row of setæ. (See fig. 1.) It seems probable that these features stand in connection with some biological peculiarities of these crayfishes. The structure of the carapace on the branchial chamber seems to be apt to retain the humidity longer on this place than if it were smooth, and this might be of use if the crayfishes should make any excursions on dry land. The inner surface of the carapace covering the branchial chamber is also very densely hairy, which would also serve the same purpose—to retain the water. The armature of the cervical groove would help to carry water (rain?) from the back to the anterior branchial opening along the cervical groove." Of *C. alleni* and *C. fallax*, which he sometimes found burrowing at considerable distance from water, he says: "The inner side of the carapace covering the branchial chamber of these *Cambari* was also very hairy; so this adaptation seems to be common to several crayfishes with similar habits." Whether the structure of the branchial chamber is to be interpreted as has been done by Lonnberg is open to doubt. Neither of the species of *Cambarus* to which he refers is known to be typical burrowing species, and, while I have satisfied myself of the hairiness of the branchiostegite of *C. gracilis* and *C. immunis*, I am not convinced that it is any more so than in forms which do not live under the same conditions, and, in case the adaptation is of the nature suggested, this would be supposed to be the case. The function suggested for the cervical groove requires no comment.

31. This conclusion is supported by what is known concerning the behavior of the burrowing species of other genera of the Astacidæ. The habits of *Parastacus*, as described by Faxon ('98) and Lonnberg ('98) seem very similar to those of certain species of *Cambarus*, and indicate an extension of the territory habitable by the species, just as we find in *C. diogenes*, *C. gracilis*, *C. immunis*, and others. The similarity of habits of *Cheraps bicarinatus* and its adaptation to life under very adverse conditions of environment are well seen from the description of its habits as quoted by Faxon ('98).

they would hardly find their proper place in an ecological paper. With the frequency and time of the occurrence, however, we are concerned. The rate of growth and frequency of exuviation in the developing *Cambarus* has not been so carefully observed as in *Astacus*, and the few notes which have been made are not of a character to justify any conclusions. As to the time of exuviation in older individuals we know a little more. According to Putnam, a female of *C. pellucidus*, about two and one-half inches in length, exuviated twice in a period of three months, January 28 to April 20, but another specimen (male or female?) of the same lot, taken in November, had been kept nearly ten months without shedding. Hargitt ('90) took animals of *C. diogenes* (?) and *C. gracilis* (?) which had recently exuviated, and also casts in the streams only in early spring. Never finding animals which had recently shed in the open water, Harris ('00) concludes that individuals of *C. gracilis* must exuviate in their burrows. For the observations on the exuviation of *C. immunis* and *C. virilis*, see the section on "Dimorphism," where it is considered in connection with the alternation of forms.

BREEDING HABITS. Data concerning the reproduction of any group of animals are admitted to be of the greatest importance. While observations are not extensive in the genus under consideration some interesting points are recorded. Some of the suggestions made by observers are based on such scanty data that they are ignored here.

The observations on conjugation need not be summarized here, since they have been so concisely stated by Mr. Andrews, the only one who has published on this subject.

The carrying of the eggs and young by the female parent need not be considered in this place.

In *C. diogenes*, the habits of which have attracted the attention of more observers than those of any other species, conjugation and the laying of eggs seem to take place in the spring. Girard ('52) found the females in the burrows carrying eggs in March and April. Tarr ('84) gives the middle of May as the approximate time of the hatching of the eggs. Hargitt ('90) observed *C. obesus* and *C. gracilis* kept in aquaria conjugating in the spring. He never found crayfishes (sp. ?) mating except in March, April, and sometimes May, and in only two in-

stances was he able to get reports of females "in berry" later than June, and then but a single individual in each case. Hay reports *C. diogenes* as in copulation in the open water April 2, eggs being laid from April 18 to 30. Harris ('02) reports a female with eggs in a not very late stage of development May 3. The taking of a female with eggs nearly ready to hatch on New Year's day, as recorded by Bundy ('77), forms an interesting exception to the above observations and suggests the laying of eggs in the fall, as has been observed in other species. The occurrence of a single individual or of a male and female in a burrow, as has been recorded by different observers, requires careful observation before any significance at all can be attribted to it in this connection. The suggestion which has been made that the burrow is designed as a retreat for the female while the eggs are hatching is no longer tenable, but that much of the period of development may be passed in the burrow is also beyond doubt.

Harris ('00 and '02) finds *C. gracilis* with a *few* young, about old enough to leave the parent, in the open ponds in early spring, and suggests that those with no young must have lost them before or immediately upon leaving the burrows in the spring. The most of the process of hatching must take place in the burrows. Hargitt ('90) noticed crayfish (*C. gracilis ?*) copulating in aquaria in the spring.

In *C. simulans*, another of the burrowing species, Harris ('02) reports females taken from burrows late in August with eggs apparently recently laid. Mrs. Cockerell states that *C. gallinas* (or *C. simulans*) taken in May had the swimmerets loaded with eggs. The differences in time are certainly interesting.

C. immunis is found in the open ponds with eggs, in the fall, and the females appear in the ponds, where the hatching of the eggs is completed, early in the spring—about March 21.

Hay ('96) reports *C. argillicola* with young as early as April 2.

Harris ('02) records *C. neglectus* with eggs and young in early June in the cold water at the mouth of a large cave in the Ozarks, and attributes the absence of eggs or young on other specimens taken in the region to the low temperature of the water at the mouth of the cave, which would retard the hatching of the eggs. Under *C. virilis* (15, ? 27) is noted a specimen, which may be *C. neglectus*, with eggs April 13.

In *C. virilis* eggs are laid in the spring, none being found on females taken during the winter. The ovarian eggs of specimens taken in January seem, so far as may be seen from a rough examination, to be fully developed.

In connection with a discussion of the breeding habits, it may be well to bring together a few observations which have been made on the habits of the young after leaving the parent.

Abbott ('73) says, in speaking of *C. affinis*, *C. acutus*, and *C. bartonii*: "The young *Cambari*, in September, seem to be fully as active as the adults, but do not frequent any given class of localities, as they wander about the beds of streams, creeping forward in a slow, awkward manner, and swimming backwards, when disturbed, with wonderful rapidity."

Williamson ('01) notes the presence of forty-seven young, varying from three-fourths to one and one-eighth inches in length, in a burrow with an adult female of *C. carolinus* on September 24. Young animals about one inch in length were taken in the small pool of water where the adults of *C. simulans* reported by Harris ('02) were taken in burrows.

Harris ('00) notes the occurrence of numbers of young crayfish, apparently *C. gracilis*, in stagnant ponds, where he had noticed young in the spring of the year, about October 20 to November 20, appearing in great numbers at about the time the adults of *C. immunis* disappeared. They were about three-fourths to seven-eighths of an inch in length. About the 1st of March of the next year they appeared before the adults, and although a few days later the pond froze over they were still to be found apparently as plentiful as ever beneath a layer of ice an inch thick. By the 1st of May they had attained a length of from one to one and one-half inches, while May 9 many small animals about five-eighths of an inch in length were observed. These were probably the young of *C. gracilis*, which are carried by the female as late as March 27. It seems, then, that young and adult *C. gracilis* appear in the ponds early in the spring and that the young again appear in the fall after the other species have gone to their burrows.

Abbott ('84) has called attention to the neatness of the chimneys constructed by the small individuals of *C. diogenes*. I have noticed the same thing in *C. gracilis* and *C. immunis* (?). As he suggests, it may have some significance.

REFERENCES TO STREAMS FROM WHICH CRAYFISH HAVE BEEN REPORTED.

I have had occasion to consult considerable literature concerned with the distribution of fresh-water forms—almost exclusively fishes—and have indexed much of what I have examined. The following list includes references to streams from which crayfish have been reported, and while almost none of them are concerned with crayfish they treat of the character of the stream or the distribution of other fresh-water organims. The list makes no pretense of completeness, but is an index to some suggestive literature, and will, I trust, prove helpful.

ALABAMA RIVER:
Adams.—Am. Nat., vol. 35, pp. 845, 846, 847. 1901.
Faxon.—Rev. Astac., p. 173.
Jordan.—Am. Nat., vol. 11, pp. 608, 610, 612. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, pp. 91, 93. 1878.
Simpson.—Sci., N. S., vol. 12, pp. 133, 134, 135. 1900.

ALLEGHANY RIVER:
Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, p. 241. 1869.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 44. 1901.

ALTAMAHA RIVER:
Faxon.—Rev. Astac., p. 173.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 91. 1878.

ANDROSCOGGIN RIVER:
Faxon.—Rev. Astac., p. 173.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 10. 1901.

APALACHICOLA AND CHATTAHOOCHEE RIVERS:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 30. 1901.

ARKANSAS RIVER:
Evermann and Kendall.—Bull. U. S. F. C., vol. 12, pp. 61-65. 1892.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 63-65. 1901.
Jordan and Gilbert.—Proc. U. S. Nat. Mus., vol. 9, p. 6. 1886.
Jordan.—Sci. Sketches, pp. 111, 113. 1888.
Meek.—Bull. U. S. F. C., vol. 14, pp. 69, 83, 86. 1894.

BIG NANCE CREEK:
Gilbert.—Bull. U. S. F. C., vol. 9, p. 444. 1889.

BIG PIGEON RIVER:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 53. 1901.

BLACK RIVER:
Meek.—Bull. U. S. F. C., vol. 14, p. 74. 1894.

BLACKSTONE RIVER:
Faxon.—Rev. Astac., p. 173.

Black Warrior River:
Adams.—Am. Nat., vol. 35, p. 845. 1901.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 32.
Gilbert.—Bull. U. S. F. C., vol. 9, p. 145. 1889.
Simpson.—Sci., N. S., vol. 12, pp. 134, 135. 1900.

Blackwater River:
Jordan.—Bull. U. S. F. C., vol. 8, p. 118. 1888.

Blue River:
Kirsch.—Bull. U. S. F. C., vol. 14, p. 33. 1894.

Boyer River:
Meek.—Bull. U. S. F. C., vol. 10, p. 248. 1890.

Brazos River:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 33, 34. 1901.
Jordan.—Sci. Sketches, p. 113. 1888.

Broad River:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 27. 1901.
Jordan.—Bull. U. S. F. C., vol. 8, p. 135. 1888.

Bull Creek:
Woolman.—Bull. U. S. F. C., vol. 10, p. 276. 1890.

Cahawba River:
Gilbert.—Bull. U. S. F. C., vol. 9, p. 145. 1889.
Simpson.—Sci., N. S., vol. 12, p. 135. 1900.

Canadian River:
Evermann and Kendall.—Bull. U. S. F. C., vol. 12, pp. 61–65. 1892.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 65, 66. 1901. (See, also, Cimarron river.)

Cape Fear River:
Faxon.—Rev. Astac., p. 173.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 25. 1901.
Jordan.—Bull. U. S. F. C., vol. 8, pp. 131–133, 135. 1888.

Catawba River:
Adams.—Am. Nat., vol. 35, p. 845. 1901.
Jordan.—Am. Nat., vol. 11, p. 608. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 91. 1878.
Jordan.—Bull. U. S. F. C., vol. 8, pp. 135, 136. 1888.
Jordan.—Sci. Sketches, p. 123. 1888.

Cedar River:
Meek.—Bull. U. S. F. C., vol. 10, pp. 230, 231. 1890.

Lake Champlain:
Faxon.—Rev. Astac., p. 174.
Jordan.—Am. Nat., vol. 11, p. 611. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 94. 1878.
Jordan.—Sci. Sketches, p. 110. 1888.

Chattahoochee River:
Adams.—Am. Nat., vol. 35, p. 845. 1901.
Faxon.—Rev. Astac., p. 173.
Hays and Campbell.—Sci., n. s., vol. 12, pp. 131, 132. 1900.
Jordan.—Am. Nat., vol. 11, pp. 608, 610. 1877.
Jordan.—Bull, U. S. Nat. Mus., No. 12, pp. 91, 93. 1878.
Jordan.—Sci. Sketches, pp. 122, 123. 1888.
Simpson.—Sci., n. s., vol. 12, pp. 134, 135. 1900.

CHESAPEAKE BAY:

Faxon.—Rev. Astac., p. 173.

CHOWAN RIVER:

Jordan.—Bull. U. S. F. C., vol. 8, pp. 118-120. 1888.

CIMARRON RIVER:

Mr. C. D. Bunker, of Oklahoma University, writes me: "The Cimarron, Canadian and Red rivers are wide sand flats, with only narrow channels of water, and the Canadian is dry most of the year, the banks are sand, and it is a rare thing to find a crayfish burrow, and rarer still to find a crayfish in the water."

CLINCH RIVER:

Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, p. 239. 1869.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 55. 1901.

Jordan.—Am. Nat., vol. 11, p. 612. 1877.

Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 95. 1878.

CONGAREE RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 27. 1901.

COOSA RIVER:

Adams.—Am. Nat., vol. 35, pp. 844, 846, 847, 848, 849. 1901.

Faxon.—Rev. Astac., p. 173.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 30, 31. 1901.

Gilbert.—Bull. U. S. F. C., vol. 9, p. 145. 1889.

Hays and Campbell.—Sci., n. s., vol. 12, pp. 131, 133. 1900.

Simpson.—Sci., n. s., vol. 12, pp. 134, 135. 1900.

CUMBERLAND RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 55-57. 1901.

Jordan.—Am. Nat., vol. 11, pp. 612, 613. 1877.

Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 95. 1878.

Jordan.—Sci. Sketches, p. 114. 1888.

Kirsch.—Bull. U. S. F. C., vol. 11, pp. 259-270. 1891.

Woolman.—Bull. U. S. F. C., vol. 10, pp. 263-268. 1890.

CYPRESS CREEK:

Meek.—Bull. U. S. F. C., vol. 9, p. 144. 1889.

DELAWARE RIVER:

Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, p. 247. 1869.

Faxon.—Rev. Astac., p. 173.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 15, 16. 1901.

Jordan.—Am. Nat., vol. 11, p. 610. 1877.

Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 93. 1878.

DES MOINES RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 78. 1901.

Meek.—Bull. U. S. F. C., vol. 10, pp. 222-225. 1890.

LAKE DRUMMOND:

Jordan.—Bull. U. S. F. C., vol. 8, p. 114. 1888.

LAKE ERIE:

Faxon.—Rev. Astac., p. 174.

Jordan.—Am. Nat., vol. 11, pp. 611, 612. 1877.

Jordan.—Bull. U. S. Nat. Mus., No. 12, pp. 94, 95. 1878.

Jordan.—Sci. Sketches, p. 127. 1888.

ESCAMBIA RIVER:

Gilbert.—Bull. U. S. F. C., vol. 9, pp. 145, 146. 1889.

ETOWAH RIVER:

Faxon.—Rev. Astac., p. 173.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 31. 1901.

Hays and Campbell.—Sci., n. s., vol. 12, pp. 131, 132, 133. 1900.

FRENCH BROAD RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 52. 1901.

Jordan.—Sci. Sketches, p. 112. 1888.

GREEN RIVER:

Woolman.—Bull. U. S. F. C., vol. 10, pp. 252-260. 1890.

GUADALUPE RIVER:

Evermann.—Bull. U. S. F. C., vol. 11, p. 72. Crayfish found in considerable numbers. 1891.

Evermann and Kendall.—Bull. U. S. F. C., vol. 12, pp. 62-65. 1892.

Jordan and Gilbert.—Proc. U. S. Nat. Mus., vol. 9, p. 23. 1886.

HICKORY CREEK:

Meek.—Bull. U. S. F. C., vol. 9, p. 126. 1889.

Meek.—Bull. U. S. F. C., vol. 10, p. 243. 1890.

HOLSTON RIVER:

Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, pp. 209, 239, 240, 241, 242, 244. 1869.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 54, 55. 1901.

Jordan.—Sci. Sketches, pp. 90, 112. 1888.

HOUSATONIC RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 13, 14. 1901.

Jordan.—Sci. Sketches, p. 116. 1888.

HUDSON BAY:

Faxon.—Rev. Astac., p. 174.

HUDSON RIVER:

Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, pp. 208, 247. 1869.

Faxon.—Rev. Astac., p. 173.

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 14. 1901.

ILLINOIS RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 60. 1901.

Jordan.—Am. Nat., vol. 11, pp. 609, 613. 1877.

Jordan.—Bull. U. S. Nat. Mus., No. 12, pp. 92, 95. 1878.

Jordan.—Sci. Sketches, p. 127. 1888.

Meek.—Bull. U. S. F. C., vol. 14, pp. 83, 86. 1894.

Dr. J. W. Beede writes: "In its lower course, the Illinois is an extremely clear, deep stream, with coarse chert gravel bottom, with narrow to wide, flat, sometimes almost swampy, flood plain. It is full of fine fish. The less swift parts are full of a coarse green plant with circlets of leaves." [Cerotophyllum ?]

INDIAN CREEK:

Meek.—Bull. U. S. F. C., vol. 10, p. 231. 1890.

IOWA RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G Surv., No. 44, p. 79. 1901.

Meek.—Bull. U. S. F. C., vol. 10, pp. 227-229, 244. 1890.

JAMES RIVER (MO.):
Meek.—Bull. U. S. F. C., vol. 9, pp. 124, 128. 1889.

JAMES RIVER (VA.):
Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, pp. 208, 209, 240, 241, 242, 246. 1869.
Faxon.—Rev. Astac., p. 173.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 22, 23. 1901.
Jordan.—Am. Nat., vol. 11, pp. 612, 613. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 95. 1878.
Jordan.—Bull. U. S. F. C., vol. 8, pp. 107-113. 1888.
Jordan.—Sci. Sketches, pp. 90, 123. 1888.

JOHNS RIVER:
Jordan.—Bull. U. S. F. C., vol. 8, p. 135. 1888.

JUNIATA RIVER:
Gannett.—Water Supp. and Papers, U. S. G. Surv., No. 44, p. 19. 1901.

KANAWHA RIVER:
Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, pp. 209, 240, 241, 242, 243, 244, 245, 246. 1869.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 46, 47, 49. 1901.
Jordan.—Sci. Sketches, p. 90. 1888.

KANSAS RIVER:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 72, 73. 1901.

KENNEBEC RIVER:
Faxon.—Rev. Astac. p. 173.
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 9. 1901.

KENTUCKY RIVER:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 57, 58. 1901.
Jordan.—Am. Nat., vol. 11, pp. 611, 612. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, pp. 91, 95. 1878.
Woolman.—Bull. U. S. F. C., vol. 10, pp. 275-281. 1890.

KIAMICHI RIVER:
Meek.—Bull. U. S. F. C., vol. 15, p. 341. 1895.

LIZARD CREEK:
Meek.—Bull. U. S. F. C., vol. 10, p. 222. 1890.

MAUMEE RIVER:
Jordan.—Am. Nat., vol. 11, p. 609. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 92. 1878.
Kirsch.—Bull. U. S. F. C., vol. 14, pp. 315-337. 1894.

MERAMEC RIVER:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 68. 1901.
Meek.—Bull. U. S. F. C., vol. 9, p. 116. 1889.

MIAMI RIVER:
Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, p. 60. 1901.
Jordan.—Am. Nat., vol. 11, p. 611. 1877.
Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 91. 1878.

LAKE MICHIGAN:

Faxon.—Rev. Astac., p. 174.

Jordan.—Bull. U. S. Nat. Mus., No. 12, p. 94. 1878.

Jordan.—Sci. Sketches, pp. 111, 127. 1888.

MILL CREEK (KAN.):

Dr. J. W. Beede writes me: "Mill creek is in the Flint Hills. Most of the course of the larger part of the stream is very muddy in the channel, with strong ripples occasionally. It is a great deal like the Wakarusa—strikingly so."

MINNESOTA RIVER:

Gannett.—Water Supp. and Irr. Papers, U. S. G. Surv., No. 44, pp. 79, 80. 1901.

MISSISSIPPI RIVER:

Adams.—Am. Nat., vol. 35, pp. 848, 849. 1901.

Cope.—Journ. Acad. Nat. Sci. Phila., ser. 2, vol. 6, p. 246. 1869.

Eigenmann.—Bull. U. S. F. C., vol. 14, pp. 101, 121. 1894.

Faxon.—Rev. Astac., pp. 173, 174.

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ZOOLOGICAL LABORATORY,
University of Kansas,
June, 1903.

INDEX.

SUBJECTS.

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KANSAS UNIVERSITY SCIENCE BULLETIN.

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LISTS OF COLEOPTERA AND LEPIDOPTERA

COLLECTED IN HAMILTON, MORTON AND CLARK COUNTIES, KANSAS, 1902 AND 1903.

BY F. H. SNOW.

A combination of two papers, read at the thirty-fifth and thirty-sixth annual meetings of the Kansas Academy of Science, January 2, 1903, and November 27, 1903.

THE following lists represent a portion of the entomological work of the two scientific collecting expeditions to southwestern Kansas in charge of the writer in the years above named. His associates in 1902 were his son, Frank L. Snow, Mr. E. S. Tucker, museum assistant in the University, and Roy Moodie and Will Bailey, students. The duration of the expedition was only three weeks, from May 30 to June 20. Two camps were occupied—the first at Shanstrom's grove, a mile and a half east of Coolidge, in Hamilton county, on the banks of the Arkansas river; the second at Point of Rocks, in Morton county, on the Cimarron river, in the extreme southwestern corner of Kansas. The writer had not previously collected insects in western Kansas farther south than Wallace county nor earlier in the season than July.

In 1903 the party consisted of Dr. C. F. Adams, Eugene Smyth, and Roy Rauch, in addition to the director, and the single camp was located at Englewood, in Clark county, about a mile from Bullard creek, a tributary of the Cimarron river, and about seven miles from the latter stream. This camp was occupied for seven weeks—from May 19 to July 1—and a careful survey was made of the entomological life of the surrounding country. As might have been expected, the character of this fauna was more Texan than had previously been observed in Kansas, our camp being only about two miles from the Oklahoma line and not more than fifty miles from the northern line of Texas.

The results of these two expeditions were extremely satisfactory, adding more than three hundred species to the lists of species previously recorded as occurring in Kansas, and furnishing valuable data for a future study of geographical distribution.

For the identification of species not readily determinable from the University collections, the writer is under obligations to Mr. Charles Liebeck and Mr. H. C. Fall.

A report on the species taken in the other orders of insects will appear at a later date.

LIST OF COLEOPTERA.

Henshaw's numbers. Abbreviations: H., for Hamilton county; M., for Morton county; C., for Clark county.

Family Cicindelidæ.

19. Cicindela scutellaris Say. H. M. C.
21. pulchra Say. H. M.
25. purpurea Oliv. C.
25*a*. audubonii Lec. C.
25*b*. graminea Schaupp. C.
25*i*. splendida var. denvereusis Casey. H. C. New to Kansas.
26. formosa Say. H. M. C.
26*b*. venusta Lec. H. C.
28. fulgida Say. H. C.
32. vulgaris Say. H. C.
33. repanda Dej. H. M. C.
33. var. unijuncta Casey. H. M. C.
35. hirticollis Say. M.
35. var. ponderosa Thompson. H. M. C.
40. punctulata Fab. H. M. C.
40*a*. micans Fab. H. M. C.
45. cuprascens Lec. C.
50. nevadica-knausii Leng. H. C. New to Kansas.
58. circumpicta Laf. C.
59. togata var. apicalis W. Horn. C.

Family Carabidæ.

124. Calosoma externum Say. C.
126. protractum Lec. C. New to Kansas.
127. scrutator Fab. H. C.
134. lugubre Lec. H. C. New to Kansas.
136. triste Lec. C.
137. obsoletum Say. H. C.
215. Pasimachus duplicatus Lec. C. New to Kansas.
217. elongatus Lec. H. M. C.
220. Scarites subterraneus Fab. C.

237. Dyschirius sphæricollis Say. H.
259. Clivina impressifrons Lec. H.
273. ferrea Lec. C.
277. postica Lec. C.
285. Schizogenius ferrugineus Putz. C.
311. Bembidium coxendix Say. H.
316. bifossulatum Lec. C.
366. cordatum Lec. C.
381. dorsale Say. H.
387. variegatum Say. H.
388. intermedium Kirby. C.
394. constrictum Lec. H.
397. dejectum Casey. H. New to Kansas.
408. dubitans Lec. H. New to Kansas.
440. Tachys corruscus Lec. H. New to Kansas.
461. incurvus Say. H.
524. Pterostichus substriatus Lec. H. M. C. Taken also in Ford county.*
525. constrictus Say. H. M. C.
555. permundus Say. H.
563. texanus Lec. H.
564. sayi Brullé. H. C.
666. Amara confusa Lec. C. New to Kansas.
682. subænea Lec. C.
683. musculus Say. H. C.
710. Diplochila laticollis Lec. H.
713. Dicælus lævipennis Lec. H. New to Kansas.
732. Badister pulchellus Lec. H. New to Kansas.
739. flavipes Lec. H. New to Kansas.
772*b*. Platynus viridis Lec. H.
773. decorus Say. H.
774*b*. texanus Lec. H.
815. placidus Say. H.
847. Casnonia pennsylvanica Linné. H. C.
851. Galerita janus Fab. H. C.
872. Lebia grandis Hentz. M. C.
882. viridis Say. H. C.
895. scapularis Dej. C.
926. Philophuga viridicollis Lec. C.
939. Cymindis laticollis Say. C.
941. planipennis Lec. H.
960. Helluomorpha texana Lec. H. C. New to Kansas.
977*a*. Brachynus similis Lec. H. New to Kansas.
983? kansanus Lec. C.
995. Chlænius fuscicornis Dej. C.
1018. tricolor Dej. C.
1021. pennsylvanicus Say. H.
1032. tomentosus Say. M. C.
1052. Geopinus incrassatus Dej. H.
1054. Nothopus zabroides Lec. M. C.

*The species credited to Ford county in this list were taken at Dodge City during a detention by washouts on the railroad while the collecting party was *en route* to Coolidge, in Hamilton county, in 1902.

1056. Cratacanthus dubius Beauv. H. M. C
1059. Agonoderus lineola Fab. H. C.
1061. pallipes Fab. H. M. C.
1067. Discoderus parallelus Hald. H. C.
1074. Gynandropus hylacis Say. H.
1083. Harpalus caliginosus Fab. H. C.
1087. pennsylvanicus De G. H. C.
1091. fallax Lec. C.
1110. funestus Lec. H. C. New to Kansas.
1125. Selenophorus pedicularius Dej. C.
1125. var. semiopacus. C. New to Kansas.
1140. Stenolophus conjunctus Say. H. C. Taken also in Ford county.
1158. Bradycellus rupestris Say. C.
1177. Anisodactylus harpaloides Laf. C. New to Kansas.
1178. dulcicollis Laf. C.
1179. opaculus Lec. C. New to Kansas.
1208. lugubris Dej. C.
1209. sericeus Harr. H.

Family HALIPLIDÆ.

1221. Haliplus triopsis Say. H.

Family DYTISCIDÆ.

1476. Eretes sticticus Linné. C.

Family GYRINIDÆ.

1536. Dineutes assimilis Aubé. C.

Family HYDROPHILIDÆ.

1546. Helophorus linearis Lec. C.
1586. Hydrophilus triangularis Say. H. C.
1589. Tropisternus nimbatus Say. C.
1597. Hydrocharis obtusatus Say. H.
1607. Berosus subsignatus Lec. C. New to Kansas.
1613. infuscatus Lec. C.
1621. Laccobius agilis Rand. C.
1634. Helochares diffusus Lec. C.
1635. fuscus Mots. H.

Family SILPHIDÆ.

1705. Silpha truncata Say. H.

Family STAPHYLINIDÆ.

2119. Creophilus villosus Grav. H.
2164. Philonthus semiruber Horn. C. New to Kansas.
2170. flavolimbatus Er. C.
2182. alumnus Er. C. New to Kansas.
2274. Xantholinus emmesus Grav. C.
2705. Bledius gularis Lec. C.
2712. armatus Er. H. New to Kansas.
2738? suturalis Lec. H. New to Kansas.

Family Phalacridæ.

2993. Phalacrus politus Melsh. H.
3005. Olibrus consimilis Marsh. H.

Family Coccinellidæ.

3046. Hippodamia convergens Guér. H. C.
3051. parenthesis Say. M.
3065. Olla oculata Fab. H. M.
3065*a*. abdominalis Say. H. M. C.
3094. Brachyacantha dentipes Fab. C.
3095*a*. decem-pustulata Melsh. C.
3095*d*. albifrons Say. C.
3101. Hyperaspis fimbriolata Melsh. M.
3126. Hyperaspidius trimaculatus Linné. H. C.

Family Erotylidæ.

3206. Languria læta Lec. H. M. C.
3209. Acropteroxys gracilis Newm. H.

Family Mycetophagidæ.

3409. Typhœa fumata Linné. C.

Family Dermestidæ.

3418. Dermestes marmoratus Say. H. C.
3418*a*. mannerheimii Lec. H. C.

Family Histeridæ.

3461. Hololepta fossularis Say. C.
3468. Hister arcuatus Say. H. New to Kansas.
3473. ulkei Horn. M. C.
3490. abbreviatus Fab. H. M. C.
3511. pollutus Lec. Taken in Ford county only.
3553. Paromalus estriatus Lec. C.
3583. Saprinus lugens Er. H. C.
3585. pennsylvanicus Payk. H. M. C.
3590. assimilis Payk. H. C.
3625. patruelis Lec. C.

Family Nitidulidæ.

3675. Carpophilus melanopterus Er. H.
3675. var. rufus Murr. H.
3719. Nitidula bipustulata Linné. C.
3720. rufipes Linné. C.
3721. ziczac Say. C.
3744? Amphicrossus ciliatus Oliv. C.

Family Monotomidæ.

3866. Hesperobænus rufipes Lec. M.

Family HETEROCERIDÆ.

3966. Heterocerus limbatus Kies. H.
3968. pallidus Say. H. C.

Family ELATERIDÆ.

4085. Lacon rectangularis Say. H. M. C.
4104. Cardiophorus cardisce Say. C.
4109. gagates Er. C. New to Kansas.
10052. Cryptohypnus cucullatus Horn. H. New to Kansas.
4185. Monocrepidius vespertinus Fab. M.
4190. auritus Hbst. C.
4190. auritus, var. C.
4253. Drasterius elegans Fab. H.
4324. Melanotus exuberans Lec. H. C. Taken also in Ford county.
4343. sagittarius Lec. C. New to Kansas.

Family BUPRESTIDÆ.

4600. Buprestis confluens Say. H.
4639. Chrysobothris femorata Fab. C.
4639*a*. alabamæ Gory. C. New to Kansas.
10071. purpureovittata Horn. C.
4699. Acmæodera pulchella Hbst. H. M. C.
4742. Agrilus politus Say. H. M.
4744. cuneus Lec. H. M. C.
4746. egenus Gory. C.
4747. lacustris Lec. C.
4750. muticus Lec. H. M. C.
4751. pulchellus Bland. C. New to Kansas.

Family LAMPYRIDÆ.

4794. Plateros modestus Say. C.
4820. Pyropyga decipens Harr. C.
4876. Chauliognathus marginatus Fab. C.
4932. Telephorus carolinus Fab. Taken in Ford county only.
4940. scitulus Say. H.

Family MALACHIDÆ.

4994. Collops tricolor Say. C.
4996. eximius Er. H. New to Kansas.
5002. bipunctatus Say. H. M.
5004. quadri-maculatus Fab. H. M. C.
5009. limbellus G. & H. H. M. C.
5040. Anthocomus ventralis Horn. M. New to Kansas.
5080. Pristocelis erythropus Lec. H.

Family CLERIDÆ.

5147. Cymatodera undulata Say. C.
5164. Clerus spinolæ Lec. M.
...... atriventris Lec. M. New to Kansas.

5195. Hydnocera pubescens Lec. M. C.
5196. scabra Lec. M. New to Kansas.
5230. Necrobia rufipes Fab. C.

Family PTINIDÆ.

5239. Ptinus fur Linné. C.
5308. Hemiptychus punctatus Lec. H.
5309. gravis Lec. H. M.
5334. Ptilinus thoracicus Rand. C.

Family SCARABÆIDÆ.

5426. Canthon ebenus Say. H. C.
5428. praticola Lec. H. C.
5435. lævis Drury. H. M. C.
5452. Phanæus carnifex Linné. H. C. Taken in Ford county also.
5458. Onthophagus hecate Panz. H. Taken also in Ford county.
5462. tuberculifrons Harold. C.
5463. pennsylvanicus Harold. H.
5482. Rhyssemus sonatus Lec. C. New to Kansas.
5490. Atænius figurator Har. H. New to Kansas.
5493. stercorator Fab. H.
5499. abditus Hald. H. C.
10191. californicus Horn. H.
5515. Aphodius denticulatus Horn. H.
5517. fimetarius Linné. C.
5528. granarius Linné. H. C.
5445. rubeolus Beauv. H.
5546. stercorosus Melsh. C.
5570. walshii Horn. H.
5578. Ochodæus musclus Say. H. C.
5581. biarmatus Lec. H. C.
5588 Bradycinetus fossator Hald. H.
5589. serratus Lec. C.
5590*a*. Bolboceras tumefactus Beauv. C.
5591. lazarus Fab. H. C.
5613. Trox scabrosus Beauv. C.
5616. suberosus Fab. H. C.
5617. punctatus Germ. H. M. C.
5618. tuberculatus De G. H.
5620. sonoræ Lec. C.
5624. sordidus Lec. C.
5630. atrox Lec. H. M.
5698? Diazus rudis Lec. H.
5717. Diplotaxis frondicola Say. H. M. C.
5737. Lachnosterna cribrosa Lec. C. New to Kansas.
5739. lanceolata Say. H. C.
5772. crassissima Blanch. H. C.
5818. Listrochelus fimbripes Lec. C. New to Kansas.
5831. Anomala binotata Gyll., var. C.
5842. Strigoderma arboricola Fab. M. C.
5851. Cotalpa lanigera Linné. C.

5858. Cyclocephala immaculata Oliv. H.
5867. Chalepus obsoletus Lec., var. H. Taken also in Ford county.
5869. Ligyrus gibbosus De G. H. C.
5871. relictus Say. H. C. Taken also in Ford county.
10277. Stephanucha pilipennis Kraatz. C.
5901. Euphoria kernii Hald. H. M. C.
5901. kernii, var. H. M.
5904. sepulchralis Fab. C.
5911. inda Linné. H. C.
5914. Cremastochilus saucius Lec. H. C.
5925. knochii Lec. H. C.
5926. nitens Lec. C.
5939. Trichius affinis Gory. C.

Family CERAMBYCIDÆ.

5963. Prionus fissicornis Hald. H. C.
5965. Homæsthesis integer Lec. H.
6038. Chion cinctus Drury. C.
6140. Batyle ignicollis Say. H. M.
6140. ignicollis, var. M.
6141. suturalis Say. H. C.
6141. var. pearsalli Bland. H. M. C. New to Kansas.
6208. Clytanthus albofasciatus Lap. C. New to Kansas.
6292. Typocerus velutinus Oliv. H.
6296. sinuatus Newm. H. M. C.
6296. sinuatus, var. H. M.
6369. Monilema annulatum Say. H. M.
6381. crassum Lec. C. New to Kansas.
6471. Ataxia crypta Say. M. C.
6490. Mecas cana Newn. H. M. C.
6492. pergrata Say. H. C.
6495. Oberea oculaticollis Say. H.
6496. var. basalis Lec. H.
6501. ocellata Hald. C.
6506. Tetrops canescens Lec. H. M. C.
6511. Tetraopes tetraophthalmus Forst. H.
6513. femoratus Lec. H. C.
6513*b*. basalis Lec. H. New to Kansas.
6513*c*. oregonensis Lec. H. New to Kansas.
6515. canescens Lec. H. M.
6516. Amphionycha flammata Newm.

Family CHRYSOMELIDÆ.

6564. Lema texana Cr. C. New to Kansas.
6574. nigrovittata Guér. C. New to Kansas.
6587. Coscinoptera axillaris Lec. H. C.
6598. Saxinis omogera Lac. H. C.
6614*a*. Cryptocephalus notatus Fab. C.
6626. confluens Say. M. C.
6658. Pachybrachys virgatus Lec. H. C.
6659. litigiosus Suffr. H. C.

6659. Pachybrachys litigiosus, var. M.
6665. pubescens Oliv. H. C.
6675. pectoralis Melsh. C.
6676. cælatus Lec. H.
6678. livens Lec. H. M. C.
6683. carbonarius Hald. H.
6740. Myochrous squamosus Lec. C.
6747. Typophorus sex-notatus Say. H.
6747. var. vittatus Horn. H.
6750. pumilus Lec. H.
6753. Metachroma angustula Cr. C.
6756. dubiosum Say. C.
6755. var. f. Horn. H.
6756. var. g. Horn. M.
10354. æneicolle Horn. C. New to Kansas.
10359. parallelum Horn. C.
10363. Graphops varians Lec. C.
10369. Colaspoides opacicollis Horn. C. New to Kansas.
6772. Chrysodina globosa Say. H. M. C.
6774. Colaspis, var. lineata. C.
6778. Notodonta tristis Oliv. C.
6789. Doryphora decem-lineata Say. H. M. C.
6795. Chrysomela exclamationis Fab. H. C.
6796. conjuncta Rog. H.
6796. var. pallida Say. M. C. New to Kansas.
6800. disrupta Rog. H. M. C.
6800. disrupta, var. M. C.
6808. scalaris Lec. C.
6821. auripennis Say. C.
6837. Lina lapponica Linné. C.
6839. scripta Fab. H.
6879. Diabrotica tricincta Say. M.
6881. duodecem-punctata Oliv. H.
6881*a*. tenella Lec. C.
6884. blandula Lec. H.
6885. vittata Fab. H.
6909. Galerucella notulata Fab. C. New to Kansas.
6913. Monoxia puncticollis Say. C.
6949. Disonycha quinque-vittata Say. H. M.
6954. abbreviata Melsh. C.
6957. triangularis Say. C.
6972. Haltica punctipennis Lec. M.
6980. Crepidodera helxines Linné. H.
10458. Phyllotreta pusilla Horn. M. New to Kansas.
7040. Chætocnema denticulata Ill. C.
7068. Microrhopala cyanea Say. M. C.
7072. Stenopodius flavidus Horn. C. New to Kansas.
7097*b*. Cassida ellipsis Lec. H. M. C.
7104. Coptocycla signifera Herbst. H.
7109. Chelymorpha argus Licht. H. M. C.

Family BRUCHIDÆ.

7124. Bruchus discoideus Say. H. M.
7136. pauperculus Lec. C.
7142. uniformis Lec. M. New to Kansas.
7143. bisignatus Horn. C.
7148. fraterculus Horn. H. M. C.
7149. amicus Horn. M.
7157. exiguus Horn. C.
10475. Zabrotes subnitens Horn. C. New to Kansas.

Family TENEBRIONIDÆ.

7167. Edrotes rotundus Say. M. C.
7177. Trimytis pruinosa Lec. H. M.
7203. Epitragus canaliculatus Say. M.
7251. Ologlyptus anastomosis Say. M.
7314. Eusattus difficilis Lec. C. New to Kansas.
7316. Eleodes obscura Say. M.
7318. suturalis Say. H. M. C.
7318*a*. texana Lec. H.
7320. tricostata Say. H. M. C.
7323. obsoleta Say. H. M. C.
7327. extricata Say. H. M. C.
7331. longicollis Lec. H.
7340. hispilabris Say. H. M. C.
7357. opaca Say. H. M. C. Taken also in Ford county.
7358. fusiformis Lec. M.
7364. Embaphion muricatum Say. H. M. C.
7416. Tenebrio obscurus Fab. H. C.
7433. Blapstinus near dilatatus Lec. C. New to Kansas.
7434. fortis Lec. C. New to Kansas.
7438. pratensis Lec. C.
7439. vestitus Lec. H. C.
7460. Ammodonus fossor Lec. C.

Family MORDELLIDÆ.

7779. Mordella melæna Germ. H. M.
7780. scutellaris Fab. H.
7784. lunulata Helm. H. New to Kansas.
...... n. sp. H. New to Kansas.
7816. Mordellistena comata Lec. C. New to Kansas.
7846. unicolor Lec. H.
7858. æthiops Smith. C. New to Kansas.
7859. texana Smith. M. New to Kansas.
7866. æmula Lec. M.

Family ANTHICIDÆ.

7918. Notoxus talpa Laf. M. C.
7922. calcaratus Horn. M. New to Kansas.
7956. Anthicus ephippium Laf. H.
7959. cervinus Laf. H.
7959. cervinus, var. H.
...... mimus Casey. H. New to Kansas.
7967. near spretus Lec. C. New to Kansas.

Family MELOIDÆ.

8024. Nemognatha lurida Lec. M. C.
8027. bicolor Lec. H. C. New to Kansas.
8031. piezata Fab. H. M. C.
8043. Gnathium minimum Say. C.
8061. Macrobasis unicolor Kirby. H.
8068. immaculata Say. H. M.
8068. var. fulvescens Lec. H. M. C.
8069. segmentata Say. H. M. C.
8079. Epicauta trichrus Pall. C.
8082. ferruginea Say. C.
8083. sericans Lec. H.
8092. maculata Say. H. M. C.
8092. maculata, var. H. M.
8104. pennsylvanica De G. C.
8109. Pyrota engelmanni Lec. C.
8114. Pyrota discoidea Lec. H. M. C. Taken also in Ford county.
8119. sinuata Oliv. C. New to Kansas.
8140. Cantharis fulvipennis Lec. C.
8145. reticulata Say. H. C.

Family RHIPIPHORIDÆ.

8174. Rhipiphorus dimidiatus Fab. C.

Family RHYNCHITIDÆ.

8215. Rhynchites hirtus Fab. H.

Family BYRSOPIDÆ.

8229. Thecesternus humeralis Say. M. C.

Family OTIORHYNCHIDÆ.

8241. Calyptillus cryptops Horn. C.
8242. Ophryastes vittatus Say. M. C. New to Kansas.
8243. tuberosus Lec. H.
8244. latirostris Lec. H. C.
8245. sulcirostris Say. C.
8249. Eupagoderes sordidus Lec. H.
8267. Peritaxia hispida Horn. C. New to Kansas.
8312. Tanymecus confertus Gyll. H.
8321. Aramigus tesselatus Say. C.
8321. tesselatus, var. H.
8324. Phacepholis obscura Horn. C. New to Kansas.
8325. candida Horn. C.

Family CURCULIONIDÆ.

8370. Apion ovale Smith. M.
8397. oblitum Smith. C.
8412. griseum Smith. M.
10822. Macrops interpunctatulus Dietz. C. New to Kansas.

10827. Macrops near montanus Dietz. C. New to Kansas.
...... Macrops sp. H.
8491. Lixus sylvius Boh. C. New to Kansas.
8493. punctinasus Lec. H.
8503. læsicollis Lec. C.
8513. Stephanocleonus plumbeus Lec. C. New to Kansas.
8515. Cleonopsis pulvereus Lec. H.
8518. Cleonus trivittatus Say. H. C.
10866. grandirostris Casey. M. New to Kansas.
8529. Dorytomus mucidus Say. H.
8536. squamosus Lec. H.
8555. Smicronyx tychoides Lec., var. H. New to Kansas.
...... undet. sp. H.
8571. Endalus limatulus Gyll. H. C.
8572. æratus Lec. H. M. New to Kansas.
8575? ovalis Lec. C. New to Kansas.
8632. Anthonomus fulvus Lec. C.
10999. albopilosus Dietz. M.
8681. Macrorhoptus estriatus Lec. H. C.
8720. Conotrachelus nivosus Lec. C.
8736. leucophæatus Fah. H. M.
8742. Rhyssematus lineaticollis Say. H. M.
8758. Acalles nobilis Lec. C. New to Kansas.
8761. turbidus Lec. M. C.
8779. Tyloderma foveolatum Say. C.
8812. Copturus nanulus Lec. C.
8814. adspersus Lec. M.
8828. Cœliodes curtus Say. C.
8872. Baris transversa Say. M. C.
8882. pruinosa Lec. C.
11127. Onychobaris millepora Casey. C. New to Kansas.
8884. Trichobaris trinotata Say. C.
8916? Calandrinus grandicollis Lec. C. New to Kansas.
8917. Centrinus scutellum-album Say. M.
8931. griseus Lec. M.
8932. decipiens Lec. M.
11166. denticornis Casey. H. M. New to Kansas.
11169. pulverulentus Casey. H. M. C.
...... undet. sp. H.

Family CALANDRIDÆ.

8978. Rhodobænus tredecimpunctatus Ill. H. M. C.
8993. Sphenophorus sculptilis Uhler. C.
8998. placidus Say. C.
9000. parvulus Gyll. C.
9027. Cossonus corticola Say. H. C.
...... Rhyncholus eximius Lec. H. New to Kansas.

Family ANTHRIBIDÆ.

9227. Brachytarsus vestitus Lec. C. New to Kansas.

SUMMARY OF SPECIES AND VARIETIES OF COLEOPTERA.

Cicindelidæ	20	Malachidæ	7
Carabidæ	76	Cleridæ	6
Haliplidæ	1	Ptinidæ	4
Dytiscidæ	1	Scarabæidæ	53
Gyrinidæ	1	Cerambycidæ	26
Hydrophilidæ	9	Chrysomelidæ	58
Silphidæ	1	Bruchidæ	8
Staphylinidæ	8	Tenebrionidæ	22
Phalacridæ	2	Mordellidæ	9
Coccinellidæ	9	Anthicidæ	7
Erotylidæ	2	Meloidæ	19
Mycetophilidæ	1	Rhipiphoridæ	1
Dermestidæ	2	Rhynchitidæ	1
Histeridæ	10	Byrsopidæ	1
Nitidulidæ	6	Otiorhynchidæ	12
Monotomidæ	1	Curculionidæ	43
Heteroceridæ	2	Calandridæ	6
Elateridæ	10	Anthribidæ	1
Buprestidæ	11	Total number	462
Lampyridæ	5		

Of the above 462 species and varieties, 79, more than one-sixth of the entire number, have not been previously taken in Kansas. Of these 79 additions to the Kansas list of Coleoptera, 47 were taken in Clark county, 25 in Hamilton county, and 7 in Morton county. Of the entire number of 462 species, 172 were taken in Clark county only, 108 in Hamilton county only, 31 in Morton county only, 49 in all three counties, 61 in both Clark and Hamilton counties, 21 in both Hamilton and Morton counties, 18 in both Clark and Morton counties, and two in Ford county only. The elevations of the three collection camps above the sea are as follows: Clark county, 1962 feet; Morton county, 3200 feet; Hamilton county, 3350 feet.

LIST OF LEPIDOPTERA.

This list contains seventy-nine species of Lepidoptera not previously included in Kansas lists. The large number of additions is partly due to the fact that no lists of Kansas Lepidoptera have been published since the author's catalogue of 503 species of the Lepidoptera of eastern Kansas (Trans. Kan. Acad. of Science, vol. IV, pp. 29–59, 1875) and his list of forty-five additional species (Trans. Kan. Acad. of Science, vol. VII, pp. 102–105, 1881).

For the determination of species not determinable from the University collections, the author is indebted to Dr. Henry Skinner, Prof. John B. Smith, and Prof. C. H. Fernald.

The numbers and nomenclature are those of Smith's check-list of 1903.

Family Nymphalidæ.

1. Danais archippus Fab. C.
2. berenice Cram. C. New to Kansas.
10. Euptoieta claudia Cram. H. C.
120. Phyciodes ismeria Bd. & Lec. C.
127. camillus Edw. H. C. New to Kansas.
131. picta Edw. C. New to Kansas.
141*b*. Grapta umbrosa Lint. C.
153. Vanessa antiopa Linn. C.
156. Pyrameis atalanta Linn. C.
158. cardui Linn. C.
184. Apatura antonia Edw. C. New to Kansas.

Family Lycænidæ.

283. Thecla melinus Hbn. C.
378. Lycæna acmon Db. & Hew. C.
387. isola Reak. C.
393. exilis Bdv. H. C. New to Kansas.

Family Papilionidæ.

407. Pieris protodice Bd. & Lec. C.
411*a*. Nathalis irene Fitch. H. C.
428. Kricogonia lycide Godt. H.
438. Colias eurytheme Bdv. C.
438*b*. keewaydin Edw. C. New to Kansas.
454. Terias nicippe Cram. C.
469. Papilio philenor Linn. C.

Family HESPERIDÆ.

512. Pamphila ottoe Edw. C. New to Kansas.
519. uncas Edw. H. C.
557. near deva Edw. C. New to Kansas.
577. vitellius Fabr. C. New to Kansas.
613. Pyrgus tessellata Scudd. H.
632. Nisoniades near tristis Bdv. C.
649. Pholisora catullus Fabr. C.
651. pirus Edw. H. New to Kansas.
676. Eudamus tityrus Fabr. H.

Family SPHINGIDÆ.

718. Lepisesia juanita Strck. H. M. C.
764*a*. Sphinx albescens Tepper. H. New to Kansas.
788. Marumba modesta Harr. C.
789*a*. Smerinthus geminatus Say. H. C.

Family SYNTOMIDÆ.

859. Scepsis fulvicollis Hbn. H.
864. Lycomorpha pholus Dru. C.

Family LITHOSIIDÆ.

880. Hypoprepia miniata Kirby. C. New to Kansas.

Family ARCTIIDÆ.

950. Estigmene acræa Dru. C.
993. Apantesis nais Dru. C.
1015. Euchætes spragueia Grt. H. C.

Family AGARISTIDÆ.

1066. Copidryas gloveri G. & R. H. New to Kansas.

Family NOCTUIDÆ.

1131. Acronycta transversata Smith. H. New to Kansas.
1152. connecta Grt. H.
1245. Caradrina extimia Walk. H. New to Kansas.
1349. Hadena semilunata Grt. H. New to Kansas.
1449. Prodenia ornithogalli Gn. C.
1692. Chorizagrotis auxiliaris Grt. C.
1693. introferens Grt. H. C. New to Kansas.
1694. agrestis Grt. H. C. New to Kansas.
1695. soror Smith. H. New to Kansas.
1989. Mamestra capsularis Gn. C.
2003. trifolii Rott. H.
2176. Leucania neptis Smith. H. New to Kansas.
2187. phragmatidicola Gn. C.
2188. imperfecta Smith. H. New to Kansas.
2491. Dasyspoudæa meadii Grt. H. C. New to Kansas.
2502. Heliocheilus paradoxus Grt. H.

2504. Heliothis armiger Hbn. C.
2505. phlogophagus Grt. C.
2507. suavis Hy. Edw. H. New to Kansas.
2508. Rhodophora gauræ S. & A. H.
2511. citronellus Grt. C. New to Kansas.
2513. Rhododipsa volupia Fitch. H. C.
2523. Pseudacontia crustaria Morr. H. New to Kansas.
2545. Schinia simplex Smith. H. C. New to Kansas.
2558. near lynx Gn. C.
2559. roseitincta Harv. C. New to Kansas.
2568. jaguarina Gn. H. C.
2597. Palada scarletina Smith. H. New to Kansas.
2673. Cirrophanus duplicatus Smith. H. New to Kansas.
2679. Stiria rugifrons Grote. H.
2711. Plusia pseudogamma Grt. C.
2744*a*. Autographa simplex Gn. C.
2773. Marasmalus inficita Walk. C.
2862. Xanthoptera near nigrofimbria Gn. H.
2890. Tornacontia sutrix Grt. H. New to Kansas.
2895. Therasea angustipennis Grt. C. New to Kansas.
2912. Acontia near biplaga Gn. C.
2935. candefacta Hbn. H. C.
2937. Fruva fasciatella Grt. C.
2995. Drasteria crassiuscula Harr. H. C. New to Kansas.
3019. Cirrhobolina deducta Morr. H. M. New to Kansas.
3020. mexicana Behr. H. M. New to Kansas.
3021. vulpina Hy. Edw. M. New to Kansas.
3033. Syneda socia Behr. H. C. New to Kansas.
3044. ingeniculata Morr. C. New to Kansas.
3217. Homoptera lunata Dru. H.
3219. rubi Hy. Edw. H. C. New to Kansas.
3237. Epizeuxis lubricalis Geyer. C.
3312. Plathypena scabra Fabr. C.

Family NOTODONTIDÆ.

3413. Schizura unicornis S. & A. H.
3424. Harpyia cinerea Wlk. H. New to Kansas.

Family LASIOCAMPIDÆ.

3470*a*. Clisiocampa incurva Hy. Edw. H. New to Kansas.

Family GEOMETRIDÆ.

3743. Hæmatopsis grataria Fabr. H.
3808. Eois perirrorata Pack. C.
3811. tacturata Walk. C. New to Kansas.
3838. Chlorochlamys chloroleucaria Gn. C.
3878. Fernaldella fimetaria G. & R. C. New to Kansas.
3898. Deilinia elimaria Hulst. H. New to Kansas.
3929. Sciagraphia punctolineata Pack. C. New to Kansas.
3948. Macaria s-signata Pack. C. New to Kansas.
4025. Euaspilates spinitaria Pack. H. C. New to Kansas.
4057. Platea trilinearia Pack. H. C. New to Kansas.

Family Cossidæ.

4487. Prionoxystus robiniæ Peck. H.

Family Sesiidæ.

4505. Melittia satyriniformis Beut. C.
4506. snowii Hy. Edw. H. New to Kansa .
4521. Memythrus cupressi Hy. Edw. H. New to Kansas.
4588. Sesia mariona Beut. C. New to Kansas.
4602. Calasesia coccinea Beut. C. New to Kansas.
4603. Paranthrene maculipes G. & R. M. C. New to Kansas.

Family Pyraustidæ.

4651. Diastictis fracturalis Zeller. H. C. New to Kansas.
4709. Nomophila noctuella S. V. C.
4725. Loxostege sticticalis Linn. H.
4726. commixtalis Wlk. H. C.
4744. vibicalis Zell. C. New to Kansas.
4754. Tholeria reversalis Gn. H. New to Kansas.
4790. Pyrausta near theseusalis Wlk. C. New to Kansas.
...... undet. sp. C.
4831. signatalis Wlk. C. New to Kansas.
4846. Eustixia octonalis Zell. C.
4849. Noctuella near thalialis Wlk. C. New to Kansas.

Family Pyralididæ.

4888. Pyralis farinalis Linn. H. C.
4905. Galasa rubidana Wlk. C.
4917*a*. Schœnobius dispersellus Rob. C. New to Kansas.
4938. Crambus leachellus Zinck. C.
4960. Crambus near ruricolellus Zell. C. New to Kansas.
4985. Thaumatopsis pexella Zell. C. New to Kansas.
4991. Ommatopteryx ocellea Haw. C. New to Kansas.
5020. Epipaschia zelleri Grt. C.
5253. Homœosoma electellum Hulst. C. New to Kansas.
5314. Cœnochroa illibella Hulst. C. New to Kansas.

Family Pterophoridæ.

5351. Pterophorus homodactylus Wlk. C. New to Kansas.

Family Tortricidæ.

5482. Eucosma quinquemaculana Rob. C.
5485. agassizii Rob. C. New to Kansas.
5501. albiguttana Zell. C. New to Kansas.
5533. pulveratana Wlsm. C. New to Kansas.
5576. Cydia striatana Clem. C. New to Kansas.
5601. vestaliana Zell. C. New to Kansas.
5605. argenticostana Wlsm. C. New to Kansas.
5614. ochreicostana Wlsm. C. New to Kansas.
5626. Proteopteryx spoliana Clem. C. New to Kansas.

5782. Archips near argyrospila Wlk. C. New to Kansas.
5783. semiferana Wlk. C. New to Kansas.
5857. Phalonia felix Wlsm. C. New to Kansas.

Family GELECHIIDÆ.

6116. Aristotelia near roseosuffusella Clem. C. New to Kansas.

Family ELACHISTIDÆ.

6646. Scythris eboracensis Zell. C. New to Kansas.

Family TINEIDÆ.

7112. Pronuba yuccasella Riley. H. M. C.
7123. Hypocolpus mortipenellus Grt. C. New to Kansas.

SUMMARY OF SPECIES OF LEPIDOPTERA.

Nymphalidæ	11	Geometridæ	10
Lycænidæ	4	Cossidæ	1
Papilionidæ	7	Sesiidæ	6
Hesperidæ	9	Pyraustidæ	11
Sphingidæ	4	Pyralidæ	10
Syntomidæ	2	Pterophoridæ	1
Lithosiidæ	1	Tortricidæ	12
Arctiidæ	3	Gelechiidæ	1
Agaristidæ	1	Elachistidæ	1
Noctuidæ	50	Tineidæ	2
Notodontidæ	2	Total number of species	150
Lasiocampidæ	1		

Of the above 150 species of Lepidoptera, 87 were taken in Clark county only, 35 in Hamilton county only, 1 in Morton county only, 2 in all three counties, 22 in both Clark and Hamilton counties, 2 in both Hamilton and Morton counties, and 1 in Clark and Morton counties.

Of the 79 species "new to Kansas," 43 were taken in Clark county only, 20 in Hamilton county only, 1 in Morton county only, 12 in Hamilton and Clark counties, 2 in Hamilton and Morton counties, and 1 in Clark and Morton counties.

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A PRELIMINARY LIST OF THE DIPTERA OF KANSAS.

BY F. H. SNOW.

NO inconsiderable amount of Kansas material in this much neglected order of insects has been accumulated in the museum of the University of Kansas as a result of the various collecting expeditions of the past twenty-five years, although chief attention has been directed to the Lepidoptera and Coleoptera. The fortunate opportunity of securing the services of Dr. C. F. Adams as a special student of the Diptera during the past year and a half has enabled the author of this paper to present this preliminary list of species.

Family CECIDOMYIDÆ (gall-gnats).

Cecidomyia destructor Say. Douglas and Sedgwick counties.

Family MYCETOPHILIDÆ (fungus-gnats).

Ceroplatus apicalis Adams, n. sp. Douglas county.
Neoglaphyroptera bivittata Say. Douglas county.
oblectabilis Loew. Douglas county.
Zygoneura toxoneura O. S. Douglas county.

Family BIBIONIDÆ (march flies).

Bibio tristis Will.
albipennis Say. Lincoln county.
femorata Wied. Douglas county.
pallipes Say. Douglas county.
Plecia heteroptera Say. Douglas county.
Dilophus stygius Say. Atchison county.

Family CULICIDÆ (mosquitoes).

Anopheles maculipennis Meig. Douglas county.
punctipennis Say.
Culex curriei Coq. Clark county.
inornatus Will. Douglas county.

Culex pungens Wied. Douglas county.
taeniorhynchus Wied. Clark county.
tarsalis Coq. Clark county.
triseriatus Say. Douglas county.
stimulans Walk. Douglas county.
Conchyliastes musicus Say. Douglas county.
Psorophora ciliata Fabr. Douglas county.

Family PSYCHODIDÆ (moth-like-flies).

Psychoda alternata Say. Douglas county.

Family CHIRONOMIDÆ (midges).

Ceratopogon argentatus Loew. Douglas county.
subasper Coq. Douglas county.
pergandei Coq. Douglas county.
albaria Coq. Douglas county.

Family TIPULIDÆ (crane-flies).

Geranomyia canadensis Westwood. Clark county.
Symplecta punctipennis Say. Clark county.

Family LEPTIDÆ (snipe-flies).

Rhachicerus obscuripennis Loew. Douglas county.
Xylomyia americana Wied. Douglas county.
pallipes Loew. Douglas county.
Chrysopila apicalis v. d. W. Douglas county.
quadrata Say. Douglas county.
foeda Loew. Douglas county.
modesta Loew. Douglas county.

Family STRATIOMYIDÆ (soldier flies).

Sargus decorus Say. Douglas county.
viridis Say. Douglas county.
Ptecticus similis Will. Douglas county.
Hermetia chrysopila Loew. Clark county.
Odontomyia binotata Loew. Douglas, Clark and Riley counties.
cincta Olivier. Douglas county.
aldrichii Johnson. Riley county.
americana Day. Morton county.
intermedia Wied. Douglas county.
nigra Day.
arcuata Loew. Clark county.
Stratiomyia apicula Loew. Douglas county.
meigenii Wied. Douglas county.
constans Loew. Clark county.
Nemotelus unicolor Loew. Douglas and Hamilton counties.
pallipes Say. Clark county.
kansensis Adams, n. sp. Clark county.
abdominalis Adams, n. sp. Clark county.

Family TABANIDÆ (horse-flies).

Chrysops sequax Will. Logan county.
œstuans Wulp. Clark county.
vittatus Wied.
fulvaster O. S. Clark county.
Silvius 4-vittatus Say. Morton and Hamilton counties.
pollinosus Will. Morton and Clark counties.
Tabanus exul O. S. Douglas and Sedgwick counties.
atratus Fabr. Clark county.
fulvulus Wied. Douglas county.
melanocerus Wied. Douglas county.
venustus O. S. Douglas, Riley and Morton counties.

Family ASILIDÆ (robber-flies).

Microstylum guenelodes Loew. Finney county.
Ospriocerus æacus Wied. Hamilton, Morton, Logan and Clark counties.
æacides Loew. Hamilton and Morton counties.
Stenopogon consanguineus Loew. Hamilton, Morton and Clark counties.
æacidinus Will. Hamilton, Morton, Wallace and Clark counties.
Stichopogon trifasciatus Say. Douglas, Hamilton, Morton, Wallace and Clark counties.
Taracticus octopunctatus Say. Douglas county.
Deromyia miscellus Loew. Douglas county.
angustiventris Macq. Wallace county.
platyptera Loew. Douglas, Sedgwick and Wallace counties.
angustipennis Loew. Wallace, Logan and Sedgwick counties.
Saropogon adustus Loew. Hamilton, Morton and Wallace counties.
combustus Loew. Hamilton, Morton, Wallace, Clark and Finney counties.
Atomosia rufipes Macq. Morton county.
Dasyllis tergissa Say. Douglas county.
Laphria canis Will. Douglas county.
Lampria rubriventris Macq. Wallace county.
Laphystia sexfasciata Say. Douglas and Clark counties.
Triclis togax Will. Douglas county.
Promachus bastardii Macq. Douglas county.
vertebratus Say. Douglas, Sedgwick and Wallace counties.
fitchii O. S. Hamilton, Morton and Clark counties.
albifacies Will. Hamilton and Morton counties.
Erax æstuans Linn. Morton and Riley counties.
cinerascens Bell. Douglas, Hamilton, Morton, Wallace, Finney and Clark counties.
varipes Will. Hamilton, Morton and Wallace counties.
leucocomus Will. Wallace county.
stamineus Will. Clark county.
tricolor Bell. Finney and Wallace counties.
Proctacanthus milbertii Macq. Douglas, Wallace, Logan and Clark counties.
philadelphicus Macq. Hamilton and Morton counties.
Asilus sericeus Say. Hamilton and Morton counties.
Rhadiurgus cirro-plaque Will. Finney and Morton counties.

Family Mydaidæ.

Mydas clavatus Dru. Douglas county.

Family Nemistrinidæ (tangle-veined flies).

Rhynchocephalus sackeni Will. Clark and Morton counties.

Family Bombyliidæ (bee flies).

Exoprosopa fascipennis Say. Douglas and Clark counties.
fasciata Macq. Douglas, Chase, Sedgwick, Riley and Logan counties.
titubans O. S. Morton and Logan counties.
decora Loew. Walllace, Finney and Clark counties.
dorcadion O. S. Wallace county.
Anthrax fulviana Say. Morton county.
sabina O. S. Clark county.
lateralis Say. Hamilton and Clark counties.
alternata Say. Clark county.
palliata Loew. Morton county.
tegminipennis Say. Clark county.
parvicornis Loew. Morton and Finney counties.
sinuosa Wied. Douglas county.
morio Linn. Finney county.
systris Coq. Hamilton county.
fulvohirta Wied. Douglas county.
nebulosa Coq. Finney and Hamilton counties.
mercedis Coq. Morton county.
eumenus O. S.? Finney county.
agrippina O. S. Hamilton county.
halcyon Say. Finney county.
Spogostylum analis Say. Douglas and Clark counties.
pauper Loew. Morton and Clark counties.
Bombylius atriceps Loew. Douglas and Hamilton counties.
fratellus Wied. Douglas county.
Comastes robustus O. S. Finney county.
Systœchus vulgaris Loew. Finney and Sedgwick counties.
candidulus Loew. Douglas county.
Sparnopolius fulvus Wied. Douglas county.
Lordotus gibbus Loew. Finney county.
Geron senilis Fabr. Hamilton, Morton and Clark counties.
Phthiria scolopax O. S. Clark county.
sulphurea Loew. Western Kansas (Williston).
Toxophora maxima Coq. Morton county.
pellicida Coq. Morton and Clark counties.

Family Therevidæ (stiletto flies).

Psilocephala rufiventris Loew. Clark county.
acuta Adams, n. sp. Clark county.
hæmorrhoidalis Macq. Douglas county.
notata Wied. Douglas county.
platancala Loew.? Hamilton and Morton counties.

Family SCENOPINIDÆ (window-flies).

Scenopinus fenestralis Fabr. Douglas county.
Metatrichia bulbosa O. S. Clark county.

Family ACROCERIDÆ (small-headed flies).

Oncodes melampus Loew. Douglas county.
pallidipennis Loew. Douglas and Clark counties.

Family EMPIDÆ (dance-flies).

Syneches rufus Loew. Douglas county.
Empis clausa Coq. Douglas county.
otiosa Coq. Douglas county.
Rhamphomyia nasoni Coq. Douglas county.
Tachydromyia pusilla Loew. Douglas county.
Platypalpus æqualis Loew. Douglas county.

Family DOLICHOPOIDÆ (long-legged flies).

Dolichopus bifractus Loew. Douglas county.
cuprinus Wied. Douglas county.
eudactylus Loew. Douglas county.
longipennis Loew. Douglas county.
ramifer Loew. Douglas county.
scapularis Loew. Douglas county.
vigitans Ald. Douglas county.
aurifacies Ald. Douglas county.
willistonii Ald. Douglas county.
reflectus Ald. Douglas county.
Pelastoneurus vagans Loew. Douglas county.
Lasiargyra albicans Loew. Douglas county.
Sympycnus nodatus Loew. Douglas county.
Hydrophorus cerutias Loew. Douglas county.
Psilopus caudatulus Loew. Douglas county.
comatus Loew. Douglas county.
patibulatus Say. Douglas county.
sipho Say. Douglas and Sedgwick counties.
flavipes Aldr. Douglas county.

Family SYRPHIDÆ (syrphus-flies).

Omegasyrphus baliopterus Loew. Clark county.
Micrŏdon pachystylum Will. Clark county.
lanceolatum Adams, n. sp. Clark county.
Paragus bicolor Fabr. Douglas county.
tibialis Fall. Douglas, Finney, Hamilton and Clark counties.
Pipiza pulchella Will. Douglas, Morton and Clark counties.
Chrysogaster nitida Wied. Douglas, Pottawatomie and Clark counties.
Platychirus hyperboreus Staeg. Douglas county.
quadratus Say. Douglas and Clark counties.
Eupeodes volucris O. S. Hamilton, Finney and Clark counties.
Syrphus americanus Wied. Douglas and Hamilton counties.
ribesii Latr. Douglas county.

Syrphus abbreviatus Sch. Douglas county.
arcuatus Fall. Finney county.
Mesograpta geminata Say. Douglas county.
marginata Say. Douglas and Clark counties.
polita Say. Douglas and Sedgwick counties.
Sphærophoria cylindrica Say. Douglas and Morton counties.
Allograpta obliqua Say. Douglas, Hamilton, Morton and Clark counties.
Baccha clavata Fabr. Douglas, Logan, Sedgwick and Clark counties.
Brachyopa vacua O. S. Douglas county.
Volucella fasciata Macq. Clark county.
Copestylum marginatum Say. Clark county.
Eristalis æneus Scop. Douglas county.
latifrons Loew. Douglas, Finney, Morton and Clark counties.
tenax Linn. Douglas county.
transversus Wied. Douglas county.
Helophilus latifrons Leow. Douglas, Finney, Morton, Wallace and Clark counties.
similis Macq. Douglas county.
Tropidia mamillata Loew. Douglas county.
quadrata Say. Douglas county.
Brachypalpus frontosus Loew. Douglas county.
Syritta pipiens Linn. Douglas, Riley and Clark counties.
Spilomyia 4-fasciata Say. Douglas county.
Milesia ornata Fabr. Douglas county.
Ceria abbreviata Loew. Hamilton county.
Cynorhina umbratilis Will. Douglas county.

Family CONOPIDÆ (thick-head flies).

Conops brachyrrhynchus Macq. Douglas county.
excisus Wied. Hamilton and Clark counties.
xanthopareus Will. Douglas and Riley counties.
obscuripennis Will. Douglas county.
fronto Will. Wallace county.
sylvosus Will. Shawnee county.
Physocephala tibialis Say. Douglas county.
affinis Will. Clark county.
Stylogaster neglecta Will. Douglas and Riley counties.
biannulata Say. Douglas county.
Oncomyia baronii Will. Douglas county.
Zodion bicolor Adams, n. sp. Douglas county.
fulvifrons Say. Douglas, Hamilton and Clark counties.
obliquefasciata Macq. Clark county.
pygmæum Will. Clark county.
abitus Adams, n. sp. Douglas county.
Myopa vesiculosa Say. Douglas county.

Family PIPUNCULIDÆ (big-eyed flies).

Pipunculus elegantulus Will. Douglas county.
cingulatus Loew. Douglas county.
nitidiventris Loew. Douglas county.
subopacus Loew. Douglas county.
subvirescens Loew. Douglas county.

Family PLATYPEZIDÆ (flat-footed flies).

Platypeza velutina Loew. Douglas county.

Family ŒSTRIDÆ (bot-flies).

Gastrophilus equi Fabr. Douglas, Riley and Hamilton counties.
nasalis Linné. Riley, Morton and Clark counties.
Hypoderma lineata Villers. Seward county.

Family TACHINIDÆ (tachina-flies).

Tachina mella Walk. Douglas county.
Cistogaster divisa Loew. Douglas county.
immaculata Macq. Douglas and Clark counties.
Gymnosoma fuliginosa Desv. Douglas and Clark counties.
Phorantha occidentis Walk. Clark county.
Trichopoda pennipes Fabr. Douglas and Atchison counties.
Myiophasia ænea Wied. Douglas county.
Cryptomeigenia theutis Walk. Douglas county.
Hypostena maculosa Coq. Douglas county.
Leucostoma atra Town. Douglas county.
Clytiomyia flava Town. Douglas, Clark and Hamilton counties.
Wahlbergia arcuata Say. Douglas county.
Hemyda aurata Desv. Douglas county.
Epigrimyia polita Town. Clark county.
Paraplagia spinosula Bigot. Hamilton county.
Plagia americana v. d. W. Douglas and Clark counties.
Siphoplagia anomala Town. Clark county.
Distichona varia v. d. W. Douglas county.
Chætoglossa picticornis Town. Douglas county.
Pachyophthalmus floridensis Town. Douglas county.
Senotainia kansensis Town. Riley county.
rubriventris Macq. Douglas, Clark and Hamilton counties.
trilineata v. d. W. Douglas and Clark counties.
Biomyia brasiliana Br. & Berg. Clark county.
Belvosia bicincta Desv. Douglas county.
bifasciata Fabr. Douglas county.
Aphria ocypterata Town. Clark county.
Ocyptera carolinæ Desv. Douglas and Clark counties.
Linnæmyia comta Fall. Douglas county.
Exorista pyste Walk. Douglas and Clark counties.
confinis Fall. Douglas county.
eudryæ Town. Douglas county.
Euphorocera claripennis Macq. Douglas county.
Phorocera doryphoræ Riley. Douglas county.
Masicera schizuræ Town. Riley county.
Frontina frenchii Will. Douglas county.
Sturmia albifrons Walk. Douglas county.
Euthera tentatrix Loew. Topeka.
Winthemia quadripustulata Fabr. Douglas county.
Paradidyma singularis Town. Morton, Hamilton and Clark counties.
Metachæta helymus Walk. Douglas county.
Phorichæta sequax Will. Douglas county.

Chætoplagia atripennis Coq. Douglas and Clark counties.
Araba tergata Coq. Clark county.
Opsidia goniodes Coq. Douglas county.
Hilarella fulvicornis Coq. Douglas county.
polita Town. Douglas county.
decens Town. Morton county.
Gonia capitata DeG. Douglas, Atchison, Hamilton and Clark counties.
frontosa Say. Hamilton county.
sagax Will. Douglas county.
senilis Will.
Cnephalia ruficauda Town. Douglas county.
Spallanzania hesperidarum Will. Douglas and Clark counties.
Chætogædia analis v. d. W. Douglas county.
Trichophora ruficauda v. d. W. Douglas county.
Cuphocera fucata v. d. W. Douglas county.
Peleteria robusta Wied. Atchison, Douglas, Clark and Hamilton counties.
Siphona geniculata DeG. Douglas county.
Jurinia apicifera Walk. Douglas and Clark counties.
smaragdina Macq. Atchison and Douglas counties.
algens Wied. Douglas county.
lateralis Macq. Douglas county.
hystricosa Will. Douglas county.
hystricoides Will. Douglas county.

Family SARCOPHAGIDÆ (flesh flies).

Sarcophaga cimbicis Town. Ford county.
carnaria Linn. Douglas county.
Tephromyia hunteri Hough. Ford county.

Family MUSCIDÆ (house-flies, blow-flies, screw-worm flies, horse-flies, etc.)

Hæmatobia serrata Desv. Douglas, Osage, Coffey and Russell counties.
Stomoxys calcitrans Linn. Douglas county.
Calliphora erythrocephala Meig. Douglas and Hamilton counties.
vomitoria Linné. Douglas and Clark counties.
Callomyia aldrichii Snow. Douglas county.
Lucilia cæsar Linn. Douglas county.
sylvarum Meig. Douglas county.
sericata Meig. Hamilton county.
Pseudopyrellia cornicina Fabr. Douglas, Morton and Clark counties.
Compsomyia macellaria Fab. Douglas, Hamilton, Morton and Clark counties.
Phormia regina Meig. Douglas, Morton and Hamilton counties.
terræ-novæ Macq. Douglas county.
Musca domestica Linn.
Cyrtoneura stabulans Fall. Douglas county.
Morellia micans Macq. Douglas county.
Myospila meditabunda Fab. Douglas county.

Family ANTHOMYIDÆ (vegetable maggots).

Anthomyia radicum Linn., var. caloptení Riley. Atchison and Brown counties.
angustifrons Meig. Douglas county.

Family MICROPEZIDÆ.

Micropeza turcana Town. Hamilton, Morton and Clark counties.
Calobata antennipennis Say. Douglas county.

Family PSILIDÆ.

Loxocera cylindrica Say. Douglas county.
pleuritica Loew. Douglas county.

Family ORTALIDÆ.

Pyrgota undata Wied. Clark county.
Rivellia quadrifasciata Macq. Douglas county.
micans Loew. Douglas and Clark counties.
variabilis Loew. Douglas county.
pallida Loew. Clark county.
Camptoneura picta Fabr. Douglas county.
Tetanops luridipennis Loew. Douglas county.
Tephronota humilis Loew. Douglas county.
Strictocephala cribrum Loew. Hamilton and Logan counties.
cribellum Loew. Clark county.
Callopistria annulipes Macq. Douglas county.
Œdopa capito Loew. Morton and Hamilton counties.
Chætopsis æna Weid. Douglas and Clark counties.
Stenomyia tenuis Loew. Douglas county.
Eumetopia rufipes Macq. Douglas county.

Family TRYPETIDÆ (apple maggots, etc.)

Straussia longipennis Wied. Douglas county.
Spilographa electa Say. Douglas and Clark counties.
Œdicarena persuasa O. S. Morton county.
diffusa Snow. Douglas, Morton, Riley and Wallace counties.
Plagiotoma obliqua Say. Sedgwick county.
Œdaspis atra Loew. Douglas county.
gibba Loew. Douglas county.
Carphotricha culta Wied. Douglas, Clark, Finney, Morton and Wallace counties.
Eurosta solidaginis Fitch. Douglas county.
Neaspilota alba Loew. Douglas, Clark, Morton and Hamilton counties.
Ensina humilis Loew. Clark county.
æqualis Loew. Douglas county.
Tephritis finalis Loew. Clark, Morton and Riley counties.
Euaresta bella Loew. Douglas county.
festiva Loew. Douglas county.
tapsetis Coq. Morton county.
Urellia abstersa Loew. Douglas and Morton counties.
actinobola v. d. W. Clark county.
solaris Loew. Western Kansas (Williston).

Family SAPROMYZIDÆ.

Lonchæa polita Say. Clark county.
Sapromyza tenuispina Loew. Hamilton county.

Family SCIOMYZIDÆ.

Tetanocera costalis Loew. Clark county.
pictipes Loew. Clark county.
Sepedon fuscipennis Loew. Clark county.
armipes Loew. Sedgwick county.

Family SCATOMYZIDÆ.

Cleigastra suisterei Town. Douglas county.

Family SEPSIDÆ.

Sepsis violacea Meig. Hamilton and Morton counties.

Family PIOPHILIDÆ (cheese maggots).

Piophila casei Linné. Douglas and Wyandotte counties.

Family EPHYDRIDÆ (water-flies).

Paralimna appendiculata Loew. Finney and Morton counties.
Brachydeutra dimidiata Loew. Douglas county.

Family DROSOPHILIDÆ (pomace-flies).

Drosophila ampelophila Loew. Douglas county.

Family OSCINIDÆ (singing-flies).

Oscinis nudiuscula Loew. Douglas county.
pallipes Loew. Douglas county.
variabilis Loew. Douglas county.
Meromyza americana Fitch. Douglas and Finney counties.
Siphonella cinerea Loew. Morton county.
Chlorops appropinqua Adams. Finney county.
assimilis Macq. Douglas, Sedgwick, and Morton counties.
cineripennis Adams. Riley county.
grata Loew. Douglas county.
maculosa Loew. Douglas county.
melanocera Loew. Douglas county.
parva Adams. Douglas county.
pullipes Coq. Morton and Finney counties.
unicolor Loew. Finney county.
vesicolor Loew. Douglas county.
Elachiptera costata Loew. Douglas county.
longula Loew. Douglas county.

Family BORBORIDÆ.

Limosina fontinalis Fall. Douglas county.
near æqualis. Douglas county.
atra Adams. n. sp. Douglas county.
setigera Adams. n. sp. Douglas county.
Borborus equinus Fall. Douglas county.
Sphærocera coprophagus. Douglas county.

Family HIPPOBOSCIDÆ (louse-flies).

Hippobosca bubonis Bachard. Douglas county.

Total, 392 species.

SUMMARY OF SPECIES OF KANSAS DIPTERA.

Cecidomyidæ	1	Platypezidæ	1
Mycetophilidæ	4	Œstridæ	3
Bibionidæ	6	Tachinidæ	65
Culicidæ	11	Sarcophagidæ	3
Psychodidæ	1	Muscidæ	16
Chironomidæ	4	Anthomyidæ	2
Tipulidæ	2	Micropezidæ	2
Leptidæ	7	Psilidæ	2
Stratiomyidæ	18	Ortalidæ	15
Tabanidæ	11	Trypetidæ	19
Asilidæ	33	Sapromyzidæ	2
Mydaidæ	1	Sciomyzidæ	4
Nemistrinidæ	1	Scatomyzidæ	1
Bombyliidæ	35	Sepsidæ	1
Therevidæ	5	Piophilidæ	1
Scenopinidæ	2	Ephrydidæ	2
Acroceridæ	2	Drosophilidæ	1
Empidæ	6	Oscinidæ	17
Dolichopodidæ	19	Borboridæ	6
Syrphidæ	37	Hippoboscidæ	1
Conopidæ	17	Total	392
Pipunculidæ	5		

I am glad to publish in connection with the preceding list descriptions of six new species included therein, by my fellow worker in entomology, Dr. Charles F. Adams:

Nemotelus abdominalis, n. sp.

Male. Head and members black, frontal triangle white, a very narrow band on apex of second antennal joint yellow, proboscis long, jointed, the distal part much longer than basal and curves downward. Thorax black, pile white, the humeri, a narrow lateral line, and halteres, except the extreme base of peduncle, white. Abdomen wholly white. Legs yellowish white, with coxæ, basal three-fourths of femora, and a narrow band on tibiæ, black. Wings hyaline, larger veins yellowish translucent, the third vein forked.

Female. Front on anterior part with a triangular white spot on each side; abdomen black, the narrow lateral margins, a broad apical band attenuated at each end on each segment, and venter in the middle, white. Otherwise it agrees with the male. Length, 4 mm.

Numerous specimens, Englewood, Clark county, Kansas. Collected during June, 1903, by Dr. F. H. Snow. Close to *N. immaculatus* John., but the color and markings of the antennæ and humeri are different.

Nemotelus kansensis, n. sp.

Male. Head and members black, shining, the frontal triangle white, pro-

boscis long, the distal portion curving downward. Thorax shining black; pile, which is most prominent on the mesonotum, white; a small spot on humeri and sometimes a very narrow line extending half-way to base of wing, white; halteres white, with base of peduncle brownish black. Abdomen wholly white, except a rather long transverse black stripe on fifth segment. Legs black; tip of femora, base and tip of tibæ, and tarsi, except last joint, which is brown, yellow. Wings hyaline, larger veins yellowish translucent, third vein forked.

Female. Similar to the male, except in following particulars: Front is sometimes without white markings, other specimens have two white dots laterally at anterior end; abdomen black, lateral margins, a triangular spot on second, third, and fourth segments, posterior margin of last segment, and a median row of small dots on venter, white. Length, 5.5 mm.

Numerous specimens of each sex, Englewood, Clark county, Kansas. Collected during June, 1903, by Dr. F. H. Snow.

Psilocephala acuta, n. sp.

Female. Head yellow, opaque; ocellar tubercle unusually prominent, front in profile slightly excavated, with a small median fissure on lower half, two velvety black spots on lower half next to eyes; pile black, face with a black spot near lower angle of eye; antennæ yellow, first joint about as long as the third, bristles black, second joint nearly as broad as the first, third pear-shaped, slightly broader than the first, base and arista brownish black, palpi yellow, with black pile, proboscis brownish; cheeks thickly covered with white pollen and pile, bristles of occiput black; upper and lower angles of eyes acute. Thorax yellow pollinose, two median brownish lines on mesonotum abbreviated behind, two sublateral ones abbreviated anteriorly, pile white, bristles of mesonotum, metapleuræ and scutellum black, the latter two in number; halteres yellowish white, with a blackish spot at junction of peduncle and knob. Abdomen brownish, apex of segments yellow, subopaque, sparse pile white and black, venter largely brownish. Legs yellow; trochanters, an indefinite ring at apex of femora, extreme tip of tibiæ, tip of first two tarsal joints, and last three joints wholly brown; pile white, bristles black. Wings hyaline, veins black, most of the cells on basal and anterior part occupied largely by grayish brown; in last four posterior cells the grayish brown is not so intense; a small spot on humeral cross-vein, one at base of second vein, and one at apex of first vein black; fourth posterior cell broadly open.

Male. A black spot at apex of frontal triangle, dorsum of abdomen light yellow, pile white, venter largely yellowish, hind coxæ and all femora largely brownish, wings nearly wholly hyaline, small grayish-brown spot in marginal, submarginal, posterior and anal cells; otherwise agrees with the female. Length, 8 mm.

One male and several females, Englewood, Clark county, Kansas. Collected during June, 1903, by Dr. F. H. Snow.

Microdon lanceolatum, n. sp.

Male. Head black, subshining, covered with brownish-yellow pile; eyes bare; antennæ black, first joint equal to the second and third together in length, second about half as long as the third, third, when viewed from the side, lanceolate, from above subconical, arista basal, nearly as long as the third antennal joint, brownish black at base, yellowish on apical two-thirds; mouth-parts brownish. Thorax black, subshining, mesonotum and scutellum thickly brownish yellow pilose, pleuræ sparsely so, scutellum without spines, halteres yellow.

Abdomen black, subshining, yellowish pilose, the third segment except largely on posterior angles, the fourth except narrow posterior border, and venter of latter, black pilose. Legs black, sparsely yellow pilose, hind metatarsi slightly incrassate, about as long as the following joints together, all pulvilli yellowish. Wings hyaline, veins black, indistinctly infuscated. Length, 12 mm.

One specimen, Englewood, Clark county, Kansas. Collected during June, 1903, by Dr. F. H. Snow.

Limosina atra, n. sp.

Female. Black throughout; antennæ porrect, third joint broader than long, arista pubescent; mesonotum slightly pollinose, scutellum opaque. Abdomen and legs entirely black. Wings subhyaline, third section of costa shorter than the second, distal section of second vein much longer than the first section of the third, third vein with a slight curvature forward, ending before apex of wing. Length, 1.5 mm.

One specimen, Douglas county, Kansas.

Limosina setigera, n. sp.

Female. Front opaque black, median line and orbits shining, occiput black, cheeks and mouth-parts largely yellowish, antennæ black, porrect, arista pubescent. Thorax black, moderately shining, bristles of anterior part of mesonotum rather strong, pleuræ with a brownish cast, scutellum opaque, halteres light brown. Abdomen and legs brownish black; first and last joints of hind tarsi black. Wings hyaline, third section of costa shorter than the second, distal section of second vein over twice as long as the first section of the third, ending in the costa considerably beyond the apex of the discal cell, third vein with a slight curvature forward, ending before tip of wing. Length, 2 mm.

Two specimens, one from Douglas county, the other from Magdalena mountains, New Mexico. The latter was taken by Dr. F. H. Snow in August, 1894.

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CONTENTS:

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THERMAL DIAGRAMS AND THEIR PRACTICAL USE.

BY HUGO DIEMER.

THE subject of this discussion is not a new one, but it is believed that the manner of presentation may be found advantageous. The indicator diagram taken from piston engines reveals the relations between pressure and volume at all points of the cycle. The area which the diagram encloses measures, when properly scaled, the amount of work done. The indicator card, in connection with a dynamometer or brake test, affords complete data as to the mechanical efficiency of a heat engine. It does not reveal *prima facie* anything with regard to the thermodynamic efficiency of an engine, or of the heat interchanges taking place during the cycle. The total area underneath any line in an indicator diagram represents foot-pounds of work done by or on the medium during the change of condition represented by that line. It would be desirable to have an instrument which might record in a similar way, by areas underneath lines, the total heat rejected or taken in by the medium during the same cycle of operations shown by the indicator diagram. The areas in this case would measure thermal units, whereas in the indicator diagram they measure foot-pounds.

In a system representing work by areas, the two factors whose product make up the area are units of force and of distance—that is, units of intensity and of extent. In a system representing heat units by areas, we will at once agree that the factor of intensity must be temperature. To the factor of extent has been given the name entropy.

The plotting of thermal diagrams with temperature and entropy as coordinates is of great practical value in investigations of thermal efficiency of heat engines. It is not only briefer than analytic methods, but it is more completely exact, since it gives the conditions existing at all points, whereas analytic methods can only establish an average condition during a certain period.

The first task in preparing the heat diagram is to define mathematically the unit of heat extent, so that it may be deduced from known properties of the medium dealt with.

Taking first the case of perfect gases:

If heat is applied to a gas, the results of the transfer may be expressed mathematically by the equation—

$$dQ = c_v dT + Apdv, \qquad (1)$$

where Q represents the heat supplied, c_v the specific heat at constant volume, dT the increase in temperature and p the pressure during the infinitesimal change in volume dv, and A the heat equivalent of work, or $\frac{1}{778}$. $c_v dT$ represents the heat involved in the temperature change, and $Apdv$ the heat equivalent of the external work.

The combined laws of Boyle and Charles for gases are expressed mathematically by the equation $pv = RT$, in which p is the pressure, v the volume, T the absolute temperature, and R a constant depending on the medium. From this equation we have:

$$p = \frac{RT}{v} \qquad (2)$$

Substituting this value of p in equation (1), we have:

$$dQ = c_v dT + ART\frac{dv}{v} \qquad (3)$$

By definition, entropy or ϕ is equal to $\int \frac{dQ}{T}$ Hence, dividing equation (3) by T, we have:

$$d\phi = \frac{dQ}{T} = c_v \frac{dT}{T} + AR\frac{dv}{v} \qquad (4)$$

The heat absorbed at constant pressure is $c_p dT$, while that required to raise the temperature at constant volume is $c_v dT$. The difference $(c_p - c_v)dT$ must be equal to the amount of heat necessary to effect expansion at constant pressure, namely, $Apdv$, or

$$(c_p - c_v)dT = Ap\frac{dv}{dT}dT \qquad (5)$$

$$(c_p - c_v) = Ap\frac{dv}{dT} \qquad (6)$$

If we consider pressure to be constant, we may differentiate the equation $pv = RT$, writing it $pdv = RdT$, and substituting this value for pdv in equation (6), we have:

$$c_p - c_v = AR \qquad (7)$$

Substituting this value for AR in equation (4), we have:

$$d\phi = c_v\frac{dT}{T} + (c_p - c_v)\frac{dv}{v} \qquad (8)$$

The general law of expansion of a perfect gas may be expressed by the equation

$$p_1 v_1^n = p_2 v_2^n = pv^n \qquad (9)$$

or, since $pv = RT$, we may write equation (9) as:

$$RTv^{n-1} = p_1 v_1^n \qquad (10)$$

or $RTv^{n-1} - p_1 v_1^n = 0$. Differentiating, we have:

$$(n-1)RTv^{n-2}dv = -Rv^{n-1}dT, \text{ or } dv = -\frac{Rv^{n-1}dT}{(n-1)RTv^{n-2}}$$

$$= -\frac{vdT}{(n-1)T}; \text{ or: } \frac{dv}{v} = -\frac{1}{n-1}\frac{dT}{T} \tag{11}$$

Substituting this value of $\frac{dv}{v}$ in equation (8), we have:

$$d\phi = c_v\frac{dT}{T} + (c_p - c_v)\left\{-\frac{1}{n-1}\frac{dT}{T}\right\} = \frac{dT}{T}\left\{\frac{nc_v - c_v - c_p + c_v}{n-1}\right\}$$

$$= \frac{dT}{T}\left[\frac{nc_v - c_p}{n-1}\right] = c_v\left[\frac{n - \frac{c_p}{c_v}}{n-1}\right]\frac{dT}{T};$$

integrating between limits T_1 and T_2 for which the entropies are ϕ_1 and ϕ_2, we have:

$$\phi_1 - \phi_2 = c_v\left[\frac{n - \frac{c_p}{c_v}}{n-1}\right] \log_e \frac{T_1}{T_2} \tag{12}$$

Equation (12) gives a means for determining the linear length of the entropy factor. The temperatures T_1 and T_2 are disclosed by the pv conditions shown by the indicator card. The exponent n is found by taking any two points on the curve, such as p_1v_1 and p_2v_2. Since we have $p_1v_1^n = p_2v_2^n$, we have, also, $\left[\frac{p_2}{p_1}\right] = \left[\frac{v_1}{v_2}\right]^n$ or, taking their logarithms, $\log p_2 - \log p_1 = n(\log v_1 - \log v_2)$. Hence,

$$n = \frac{\log p_2 - \log p_1}{\log v_1 - \log v_2}, \text{ or, } n = \frac{\log p_1 - \log p_2}{\log v_2 - \log v_1}$$

For accurate work, a number of points should be taken, the method of least squares being used if the requirements of the calculation demand it.

In the case of vapors such as steam, ether, alcohol, etc., the general case is that in which a part x of original liquid has been converted into vapor, the portion $1 - x$ remaining liquid. If a unit weight be considered as raised from the freezing-point to a temperature T_1 and the part x is evaporated at that temperature, the increase in entropy takes place in two stages, that of the liquid part and that of the vapor part.

If the heat contained in the liquid part be denoted by q, then the entropy of the liquid,

$$\frac{dq}{T} = \int_{T_{32}}^{T} dq = c_v \int_{T_{32}}^{T} \frac{dT}{T} = c_v \log_e \frac{T}{T_{32}}$$

Owing to the differing of the specific heat at different temperatures, this value for entropy of the liquid should be built up of small values corresponding to small increments of temperature, using the value of the specific heat corresponding to the temperature range taken.

In order to determine the entropy of the vapor portion, if r represents the latent heat of vaporization at the temperature at which

vaporization takes place, the entropy of vaporization will be $\frac{xr}{T}$, and the total entropy of the liquid and vapor will be

$$\frac{xr}{T} + c_v \log_e \frac{T}{T_{32}}$$

To show the connection between the entropy diagram and the steam-engine-indicator diagram, it is best to consider the thermodynamic action of the whole system—boiler, engine, condenser, and feed-water heater. Although the consecutive operations for turning heat into work take place in different organs of the system, these consecutive operations may be considered as the successive phases of a closed cycle in which we have (see fig. 1), first, the line *ab*, representing evaporation of the liquid in the boiler, at temperature *T*, into steam of quality of dryness *x*. Work is done during this process at constant pressure on the piston. The volume of the pound of water will

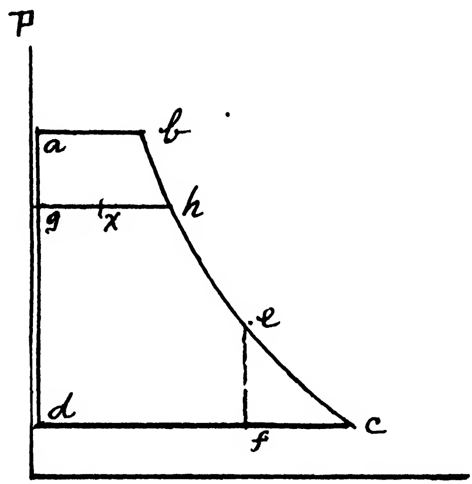

Fig. 1.

not vary very much from .017 cubic feet; *b* represents the volume of the pound of liquid after it has been expanded into steam. Assuming that evaporation has taken place, suppose the steam to be allowed to expand in such a manner that at all pressures it remains dry; that is, none of it condenses, and it is not superheated. We may plot these volumes at various pressures by inserting the known specific volumes of steam. The line *bc* is thus plotted. The next process in the system as a whole is the behavior, after expansion, of this one pound of steam at temperature 212° F. and atmospheric pressure. This step is condensation into feed water. This condensation occurs at constant pressure of the atmosphere, and will consequently be represented by the constant pressure line *cd*, indicating a diminution in volume from about 26 cubic feet to about .017 cubic feet. The last stage is repre-

sented by the supplying of heat from the source of heat between temperatures T_2 and T_1, or 212° F., and the temperature corresponding to the initial pressure. The cycle of operations just described is what is known as the Rankine ideal steam-engine cycle, and has been adopted by the British Institute of Civil Engineers as the standard for comparison of thermodynamic efficiencies of steam-engines.

Let us now trace out the corresponding entropy diagram:

At state *a* we have one pound of water whose temperature is known. The entropy of the liquid, $c_v \log_e \frac{T}{T_{32}}$, calculated by the increment method already referred to, may be found in tables prepared by Peabody and others.

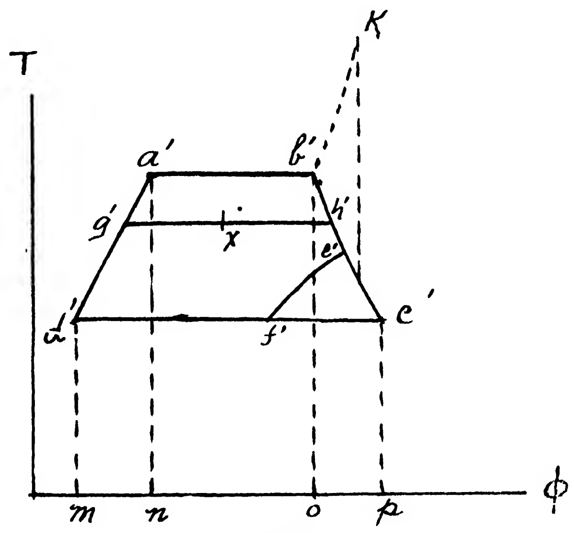

Fig. 2.

Plotting a suitable distance on the Y axis to represent the temperature, we plot a suitable distance to scale, horizontally to the right to represent the entropy of the liquid, found as above indicated, thus locating the point a' (fig. 2); b' is located by adding the entropy of vaporization, that is, $\frac{xr}{T}$, or, for complete evaporation, $\frac{r}{T}$. If the X axis has been taken as representing 32° F., the rectangle underneath $a'b'$ will represent to scale the latent heat of vaporization. This gives us the means for determining the area corresponding to one heat unit.

Points on the curve $b'c'$ are found by calculating the entropy values belonging to the respective temperatures corresponding to selected pressures; $c'd'$ represents abstraction of heat at constant temperature, and $d'a'$ represents supply of heat to the water in the boiler. The area $md'rn$ represents the heat required to heat the feed water from 32° F.

to the boiling-point; the area $md'a'n$ represents the heat required to heat the water to the point of vaporization; $na'b'o$ is the heat taken in during evaporation; $pc'd'm$ is the heat rejected during exhaust; $a'b'c'd'$ is the heat equivalent of the work done.

In actual engines, the expansion, instead of being carried to atmospheric pressure, will stop at some point such as e (fig. 1), by the opening of the exhaust, and there is a drop in pressure and temperature approaching a constant-volume line, ef. In order to plot ef on the $T\phi$ coordinates, we might find temperatures corresponding to slight drops in pressure, and find the corresponding entropy values from the formula:

$$\int \frac{dQ}{T} = c_v \, log_e \frac{T}{T_2}.$$

The curve may also be plotted graphically by making use of the principle that corresponding points in each diagram divide the horizontal lines through them in the same proportion. For example, to transfer the point x from the pv diagram to the $T\phi$ diagram: Draw a horizontal gh through x, and draw also g^1h^1 at the temperature corresponding to the pressure at g. Divide g^1h^1 in x^1 in the same proportion as gh is divided in x. Then we know that the percentage of water evaporated, when x denotes its condition as to quality of dryness, will be in the same ratio to gh, denoting complete evaporation, as the heat required for partial evaporation will be to the heat required for complete evaporation; hence, $\frac{gx}{gh} = \frac{g^1x^1}{g^1h^1}$.

In order to apply this principle to transfer the constant-volume line ef to the entropy diagram, we need simply take a number of points on the line ef, pass horizontals through them, and draw the corresponding horizontals on the entropy diagram, dividing the latter set in the same proportion that the horizontals were divided in the pv diagram by the line ef.

It is evident that we may thus transfer any number of constant-volume and constant-pressure lines to the entropy diagram, and that, if a sufficient number are plotted, the diagram becomes a chart which can be prepared in form for blue-printing or other method of duplication, and that any points, p_1v_1, p_2v_2, etc., may be exactly transferred onto the chart by finding the intersection of the constant-volume and constant-pressure lines corresponding to p_1v_1, p_2v_2, etc., on the entropy chart.

As the chart represents the behavior of one pound of feed, it is necessary, however, to transform an actual indicator diagram into a diagram representing the behavior of one pound of steam before the transfer to the entropy chart is made. This is done by measuring the amount of cylinder feed by a water meter in the feed-water pipe, or

by using a graduated feed-water supply tank, and obtaining the number of strokes per pound of cylinder feed, in case the boiler supplies but the one engine, the necessary deduction being made for the feed pump. In case there are other steam-consuming organs besides the engine under test, the exhaust steam of the engine must be the gauge of the weight of cylinder feed.

A Rankine ideal engine cycle is next constructed for one pound of steam. The average indicator card of the engine is next transformed into a *pv* diagram for one pound of feed and superposed on the Rankine diagram, the relative clearance volume being added to the displacement volume shown by the indicator card. Or, the indicator card itself may be surrounded by the Rankine ideal cycle for the weight involved in the indicator diagram and a reduction factor employed in the transfer to the entropy chart.

Superheating effects are shown on the $T\phi$ diagram by making use of the fact that entropy of superheating must be equal to specific heat of superheated steam $\times \log_e \frac{T_{sup}}{T_{sat}}$. By taking intermediate temperatures between the temperature of the superheating and that of saturation, the curve $b'k$ (fig. 2) is obtained. If, in transferring the indicator card to the entropy chart, it is found that the volume is greater than that of saturated steam, use must be made of the relation, experimentally determined, that exists between the pressure, volume and temperature of superheated steam, as expressed by Peabody, namely : $pv_{sup} = 93.5\ T_{sup} - 971\ p^{1/4}$, to determine the temperature of superheating.

Thermal diagrams constructed in accordance with the above methods, added to the information given by the indicator card and other data usually taken during an engine test, disclose completely all heat interchanges and heat relationships. The degree of refinement to which calculations based upon them can safely be carried depends necessarily upon the refinement and accuracy of the observational data from which they have been built.

In order to apply the thermal diagram to gas-engines, it is necessary to know the specific heats of the mixture used. The relative weights must be known of exhaust products, fuel charge, and air, also the chemical composition of both fuel and exhaust. The specific heats of each part multiplied by the percentage of weight it represents gives its relative specific heat, the total specific heat being the sum of these individual relative heats.

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SOME CITY WATER-SUPPLIES.

BY E. H. S. BAILEY AND EDWARD BARTOW.

THERE are practically five sources of supply for cities in the Missouri valley, viz.: (1) Rivers; (2) points or wells sunk into the soil near the bank or in the belt of the river; (3) wells; (4) artesian wells, or those that are bored to great depth; (5) ponds or lakes.

Local conditions in each case must determine which shall be the source of supply, but it often happens that from a financial standpoint one source of supply would be selected, while from the standpoint of wholesomeness of water an entirely different water would be used. Rivers are liable to be contaminated from the sewerage of towns, or from the barn-yards, stock pens or hog wallows on their banks; and the same remark applies to ponds and lakes. The water of a well may or may not be pure, according as the well is or is not properly situated with reference to drainage, sewerage, and other sources of filth.

In Kansas and vicinity a large number of cities draw their water-supply from wells, because that is the only feasible source. There are in Kansas the following river systems where the water is abundant enough to be used as a source of public supply, viz.: (1) Missouri, (2) Kaw, (3) Marais des Cygnes, (4) Neosho, (5) Verdigris, and (6) Arkansas. On these streams are situated the largest cities and villages, and so on these streams and their larger tributaries are most of the plants for supplying water to the public.

Some years ago a thorough analysis was made of the water of the Kaw valley system, during the winter stage, and this

report was published in the *University Quarterly*.[1] A series of analyses of the Kaw river at Lawrence has also been made, and a report on the analyses of the water, made during several months of the year 1903, will appear in the Division of Hydrography, United States Geological Survey. During the last year we have made some analyses of the waters of the Neosho river system. There are quite a number of cities on the upper waters of this stream that are dependent on small creeks running into the Neosho for their supply. We refer especially to Florence, Peabody, Marion, Council Grove, White City, and Cottonwood Falls. Beginning with Emporia, the following cities are dependent on the Neosho river directly for their water, viz.: Burlington, Iola, Chanute, Parsons, and Oswego. Analyses of Burlington and Iola water were made some time ago. The source of the Parsons water is a small stream and pond tributary to the Neosho. The following towns, situated on or near the Neosho river, are not yet supplied by public water-works: Le Roy, Neosho Falls, Yates Center, Humboldt, Erie, and Chetopa. We have taken up especially the water-supply of Chanute, Oswego, and Chetopa.

THE NEOSHO RIVER SYSTEM.

The city of Chanute is one of the largest of those that draw their public water-supply from the Neosho river. On May 1 of this year one of us[2] visited this city for the purpose of getting samples of the water for analysis. The water-works, which are owned by the city, are about one and a half miles east of the city, on the west bank of the river. Worthington pumps are used to pump the water from the river to the settling-basins during the night, and to force it into the city mains during the day. Although the pump-house is well above the river bank, the pumps are down nearly to the river level, so as to avoid suction as much as possible.

There are two settling-basins, which are said to have a capacity of 2,500,000 gallons each. These basins are lined with cement, and are connected through a gallery filled with gravel and sand. The material in the filter is, however, not often changed. The basins are cleaned about once a year, or when-

. *Kansas University Quarterly*, vol. III, pp. 1-12.
University Science Bulletin, vol. I, pp. 99-111.

ailey.

ever the mud has accumulated sufficiently. At the time the sample was taken the water in the river was only slightly above medium height, and was clearer than usual for that time of the year, as it had not been rendered turbid by recent rains.

The capacity of the pump is 1,000,000 gallons per day, but it is not running up to its maximum. The river is usually much higher in the latter part of May and in June, but gets to the worst and lowest stage in August or September. At the latter date it does not flow rapidly and is covered with a green scum, indicating vegetable growth. When the water is at its flood stage, the river carries a large amount of silt, dead animals, trees and all sorts of floating rubbish. A stream runs into the river some distance north of the city, which in high water is liable to bring considerable contamination to the water, as there are slaughter-houses upon its banks.

During the flood stage of the Neosho, the water covers the bottoms and is up around the pump-house, but it has not covered the basins for some years. The city water is not very extensively used for drinking purposes, as many of the people still use wells and cisterns. There were some cases of typhoid fever, but there are not sufficient data to tell whether they are in families using city water or not. The city has a sewer system, which it is rapidly extending. The outlet is into the river, at a point below the water-works. The pipes of the water company are also being extended rapidly into the outlying parts of the city, to accommodate the increasing population.

The analysis which is given below, from what has been said, evidently represents the water when in a good condition, better than the average. A sample was taken from the river opposite the pumping station, from the second settling-basin, and from the city mains in Doctor Lardner's office.

SANITARY ANALYSIS OF CHANUTE WATER-SUPPLY.

Parts per million.	Neosho river.	Settling-basin.	Service pipe.
Total solids	414.8	412	457
Loss on ignition	48.	12.8	12.5
Chlorin	9.07	9.21	8.50
Free ammonia	.011	.034	.052
Albuminoid ammonia	.199	.332	.351
Nitrogen in nitrates	.979	.960	.946
Nitrogen in nitrites	.000	.000	.000
Oxygen consumed	2.58	3.00	2.27
Hardness	207.7	201.2	202.5

From the analysis the following conclusions are drawn:

1. The amount of total solids, which means the mineral matter left on the evaporation of the water, is not large, as compared with some of the other streams of the state. The Kaw river above Lawrence is often 760, as compared with 414 in the Neosho. The constituents of this mineral matter will be considered later.

2. The chlorin, which usually represents the amount of salt in the water, is low in the Neosho, as in the drainage basin there are no alkali plains or salt marshes.

3. The free ammonia, which is regarded largely as an index of the animal matter in the water, is not high in any sample. It is, however, not as good in the sample taken from the pipes as in the untreated river water. This would indicate that, on account of the large amount of organic matter in the water, a partial decomposition takes place in the pipes, under some conditions, so that more free ammonia is generated. The sample taken from the pipes was not as clear as that taken from the river.

4. The amount of albuminoid ammonia is large; in fact, it is too high for a good water. Here, also, the river water was better than that in the pipes. It is probable that this varies with the time allowed for settling and the frequency with which the pipes are flushed out. This part of the analysis shows that the amount of organic matter, particularly that of vegetable origin, is too great. Much of this could be removed by treatment with a coagulant and subsequent filtration, as in the case of the Oswego water, which is noticed elsewhere, and which is also taken from the Neosho river.

5. The amount of nitrogen as nitrates is not excessive, and represents the results of oxidation of organic matter in the soil and in the flowing stream.

From all the data obtained, then, it is evident that the water-supply is not very satisfactory, even at this stage of the river. A more definite opinion of the water can be given when its composition at the lowest stage and at the flood stage also is known.

The last town in the state having a public water-supply from the Neosho river is Oswego, the county-seat of Labette county. The water plant is owned by a private company, and is situ-

ated on the border of the city park, in a wooded ravine, above the high-water line, northeast of the city. The Neosho at this point runs nearly east, and the banks are well wooded and high.

The water is drawn from the river by a fourteen-inch pipe, and then forced into the city mains through Jackson filters, sometimes after being treated with a little alum to act as a coagulant. The amount of alum used depends on the turbidity of the water. The sand in the filters is cleaned by reversing the current of the water as often as the pressure shows that this is necessary. About 250,000 gallons is pumped in twenty-four hours, although the capacity of the plant is four times that amount.

As the population of the city is not very large, and so many of the citizens use the water of wells and cisterns, the demand upon the water company is not very great. The experience of the company in regard to purification of the water is, that any amount of coagulant will not clarify the water at certain stages of turbidity.

Three samples of water were taken; the first from the pipe that draws the water from the river, the second from the pipe as it conveys the water to the city, and the third from the service pipe in Kingman's drug store.

SANITARY ANALYSIS OF OSWEGO WATER-SUPPLY.

Sample taken May 2, 1903.

Parts per million.	Neosho river.	Filtered water.	Service pipe.
Total solids	430	320.4	312.8
Loss on ignition	18	20.7	15.1
Chlorin	7.23	6.80	7.08
Free ammonia	.098	.030	.020
Albuminoid ammonia	.418	.234	.184
Nitrogen in nitrates	.415	.881	.314
Nitrogen in nitrites	.000	.000	.000
Oxygen consumed	5.67	3.12	2.90
Hardness	164.4	165.8	163.1

A consideration of these analyses shows the following:

1. The total solids or mineral matter is reduced twenty-seven per cent. by the process of filtration. If alum is not used, it is practically the suspended matter which is taken out. It will be noticed that the amount of total solids is not very different from that at Chanute, more than fifty miles further up the stream.

2. The amount of chlorin or consequently of common salt is small, a little less than at Chanute, which may be due to dilution with pure waters.

3. The free ammonia, though rather high in the unfiltered water, is very materially diminished by filtration, and thus the water is improved.

4. The albuminoid ammonia, which is excessive in the original water, is very much diminished in the sample supplied to the city, showing that much of the vegetable or organic matter has been removed.

Considering the whole analysis, then, it is evident that the water is greatly improved by this kind of filtration, and the water that is furnished is of fair quality. There is no doubt that when the water is at its flood stage, without further treatment, it would be difficult to furnish a water that is entirely satisfactory.

NEOSHO RIVER AT CHETOPA.

Chetopa is situated on the right bank of the Neosho, at a point where there is a sharp curve towards the east. Beyond the city the river runs for six or eight miles before it flows out of the state. As at other points along the river, the difference in the height of the water produces a great difference in its quality and in the rate of flow. During the flood season the river has been twenty-five feet higher than under ordinary conditions.

There is no public water service here, but water is pumped from the river to a tank in the city to use for sprinkling purposes.

As this is the last town of any size in the state on the river, the analysis of the water was made, for comparison with others farther up the stream.

SANITARY ANALYSIS OF THE NEOSHO RIVER AT CHETOPA.

Sample taken May 2, 1903.	Parts per million.
Total solids	390.4
Loss on ignition	18.9
Chlorin	7.60
Free ammonia	.060
Albuminoid ammonia	.363
Nitrogen in nitrates	1.021
Nitrogen in nitrites	.000
Oxygen consumed	3.82
Hardness	176.2

The analysis shows that the untreated water is better at Chetopa than at Oswego. This may be partly due to dilution of the water by Labette creek, and partly to sedimentation and oxidation.

In order to more fully understand the water of the Neosho system, a mineral analysis was made by Mr. C. F. Gustafsen of a sample taken in Doctor Lardner's office in Chanute. The following is the result:

Grams per liter.

IONS.		RADICALS.	
Calcium (Ca.)	.0756	Calcium oxid (CaO)	.1058
Magnesium (Mg)	.0004	Magnesium oxid (MgO)	.0007
Chlorin (Cl)	.0085	Ferric oxid (Fe_2O_3) / Aluminum oxid (Al_2O_3)	.0294
Sulfuric acid ion (SO_4)	.0491	Chlorin (Cl)	.0085
Silicic acid ion (SiO_2)	.0796	Sulfuric anhydrid (SO_3)	.0409
		Silicic anhydrid (SiO_2)	.0796

The above constituents may be hypothetically combined as follows:

	Grams per liter.	Grains per gallon.
Sodium chlorid (NaCl)	.0140	.818
Sodium sulfate (Na_2SO_4)	.0577	3.370
Calcium bicarbonate ($CaH_2(CO_3)_2$)	.1783	10.414
Calcium sulfate ($CaSO_4$)	.0144	.841
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	.0015	.088
Oxids of iron and alumina	.0294	1.717
Silica (SiO_2)	.0796	4.649
Totals	.3749	21.897

This analysis shows the water to be of excellent quality, as far as the mineral matter is concerned. The total solid matter (21.897 grains per gallon) is not as high as that found in many of the other rivers of the state. On this account, then, the water is well adapted to domestic and boiler use. The chief mineral substance present in the water is calcium carbonate, and that can be readily removed by treatment with a little milk of lime or by the use of washing soda.

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SOME MOLECULAR WEIGHT DETERMINATIONS,

USING A MODIFIED FORM OF BECKMANN'S BOILING-POINT APPARATUS.

BY HERBERT A. CLARK.

With plate VI.

THE following work was undertaken to test a modified form of Beckmann's boiling-point apparatus, devised and made by Dr. E. C. Franklin.[1] The original intention was to determine the molecular weights of several substances by the boiling-point method, and to compare the results, as well as the accuracy and convenience of manipulation, with corresponding factors for the ordinary Beckmann apparatus, and also to confirm the observations of Franklin and Kraus[2] that the height of the liquid over the bulb of the thermometer has a marked effect on the readings of this instrument.

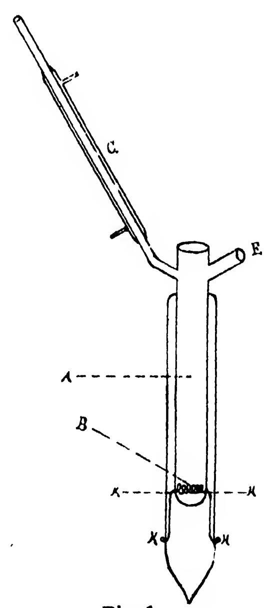


Fig. 1.

The particular piece of apparatus used in this work is represented by figure 1, which is one-sixth natural size. It consists essentially of a Dewar tube, A, with a coil of fine platinum wire, B, in the bottom, and a water-jacketed condenser, C, leading up from the top. The side tube, E, allows the insertion of a solute, or of more of the solvent, without disturbing the

1. Franklin and Kraus, Am. Chem. Jour., 20, 836 (1898).
2. Am. Chem. Jour., 20, 839 (1898).

thermometer. Both walls of the vacuum jacket are silvered from the top to the bottom of the inner tube, to prevent radiation, and so the usual platinum cylinder about the thermometer bulb is unnecessary; this avoids differences in concentration in the tube, due to water returned from the condenser. There is a question, however, whether the lack of the platinum cylinder does not cause a slight variable depression of the boiling-point, due to the cooler water from the condenser. Heat is supplied by passing an electric current through coil *B*, which is welded to heavy platinum terminals, *HH*, *KK*, passing through both walls of the Dewar tube. The resistance of the coil at 100° C. is 1.39 ohms.

It is a very simple piece of apparatus to handle, as it is all welded into one piece, with the exception of the outer wall of the condenser; this is removable, as in the ordinary Liebig form. An ordinary Beckmann thermometer, graduated in hundredths, made by F. O. R. Goetze, in Leipzig, was used. When in use, the heating coil was covered to a depth of 2.5 cm. with garnets, and the lower end of the thermometer bulb was put about 1 cm. above the garnets. It was found that a current of 3.8 amperes through the cell would cause 10 c.c. of water, just enough to cover the thermometer bulb, to boil; and that any current from 4.4 to 4.8 amperes (27 to 32 watts) would cause a very steady boiling, with any amount of water in the tube, from 10 c.c. up to 30 c.c. Any greater volume up to 45 c.c., enough to make the water bubble to the top of the Dewar tube, gave a rather variable boiling-point, probably due to the cooling effect of the upper part of the tube which was in contact with the outer air. The current was furnished by a storage battery, was measured with a Weston ammeter reading to tenths, and was controlled by a rheostat.

In the course of a set of readings, the thermometer was read twice with an interval of five minutes, with the same amount of solute and of the solvent; and the average of these two readings was taken as the correct reading for that condition. When the condition was changed by adding more of either the solute or of the solvent, an interval of ten minutes was allowed to let the thermometer become stationary. It was found that the two readings for the same condition rarely differed more than from .001° to .004°, unless there were more than 30 c.c. of liquid in

the tube. The barometer was read between the two readings of the Beckmann thermometer for each condition. The tube was carefully cleaned and dried just before each set of readings. The volume of water was measured with a pipette graduated in tenths. No correction was made for the amount of water clinging to the sides of the tube or of the condenser while the tube was in use. The water used was double distilled from acid and alkaline permanganate solutions, condensed in a block-tin condenser, and kept in a rubber-stoppered Jena flask. No test was made of the purity of the water.

Cane sugar, common salt, and urea are the only solutes investigated so far. The first was a commercial article; the last two were chemically pure, the latter having been made by C. A. F. Kaulbaum. The molecular weight was calculated according to the formula, $M = \frac{Cw}{RW}$; in which w is the weight of the solute in grams; R is the elevation of the boiling-point in degrees; W is the weight of the solvent (assumed to be numerically equal to the volume); and C is the molecular elevation constant for water, obtained from the equation, $C = \frac{2T^2}{L}$, but here assumed to be 520—a value about one per cent. too large at this altitude. The salt and sugar were compressed into pellets to avoid loss in handling, and large crystals of urea were selected for the same reason. As there is about 6.5 volts difference of potential between the ends of the heating coil when the liquid is boiling steadily, the salt was decomposed sufficiently to give a strong odor of chlorine, after the tube and contents were allowed to cool. Thus no dependence is placed on this form of apparatus for work with conducting solutions, and the results obtained with sodium chloride are not here recorded.

As will be seen from table A, the calculated molecular weight of cane sugar varies from 314 to 271 with increasing concentration varying from 17.5 g. of sugar per 100 c.c. of water to 82.6 g. per 100 c.c.; this is much less variation than was obtained by Kahlenberg.[3]

Table B shows the molecular weight of urea, varying from 66.1 with a concentration of 1.51 g. per 100 c.c. of water, to 63.8 with a concentration of 3.03 g., to 64.8 with a concentration of 7.53, and falling to a minimum of 60.4 with a concen-

3. Jour. Phys. Chem., 5, 339 (1901).

TABLE A.—CANE SUGAR.

Barometric variation, 1 mm. Variation of room temperature, 8.6°.

Amount of sugar in 20.27 g. water.	Concentration in grams per 100 c.c.	Boiling-point elevation.	Elevation corrected for barometer and room temp.	Elevation corrected for volume also.	Mol. weight (from column 4).	Mol. weight (from column 5).
1.49 g.	7.35	.119°	.134°	.132°	289	290
3.55	17.5	.286	.298	.290	306	314
5.64	27.9	.459	.475	.465	307	311
7.74	38.1	.653	.669	.657	297	303
10.13	50.1	.868	.884	.869	295	299
12.50	61.8	1.101	1.128	1.108	287	290
14.95	73.8	1.347	1.392	1.368	275	281
16.74	82.6	1.572	1.614	1.586	268	271

TABLE B.—UREA.

Barometric variation, .68 mm. Variation of room temperature, 1.3°.

Amount of urea in 20.12 g. water.	Concentration in grams per 100 c c.	Boiling-point elevation.	Elevation corrected for barometer and room temp.	Elevation corrected for volume also.	Mol. weight (from column 4).	Mol. weight (from column 5).
.304 g.	1.51	.130°	.119°	.119°	66.1	66.1
.609	3.03	.260	.247	.247	63.8	63.8
.892	4.44	.376	.360	.359	64.1	64.3
1.214	6.04	.510	.490	.488	64.1	64.3
1.513	7.53	.634	.617	.615	64.5	64.8
2.134	10.60	.914	.896	.893	61.5	61.7
2.929	14.55	1.259	1.234	1.230	61.3	61.5
3.771	18.75	1.619	1.606	1.600	60.6	60.8
4.574	22.75	1.977	1.960	1.952	60.4	60.6
5.389	26.80	2.335	2.315	2.305	60.2	60.4

tration of 26.8 g. Dieterici,[4] however, has concluded from his freezing-point determinations that the molecular lowering of the vapor tension of both cane sugar and urea increases with the concentration, between 0.1 and 1.0 normal; while, according to these results, the molecular lowering of the vapor tension in the case of urea *decreases* from a concentration of 3.03 g. per 100 c.c. to 7.53 per 100 c.c. (from .52 to 1.3 normal), and then increases. There is an apparent increase for concentrations less than 3.03 in the case of urea, shown by only two readings; and an apparent *decrease* in the case of cane sugar at a corresponding point. The first reading in each set of readings cannot be depended upon, however, as the probable error is large. The first reading, in most cases, seems to be abnormal when compared with the rest of the readings in the same series.

4. Wied. Ann., 62, 616 (1897).

In both tables, two sets of values for the molecular weight are given : one obtained from data in which the boiling-point elevations are corrected for change of barometer, after the barometer readings have been corrected for change of room temperature ; and another in which these two corrections are made, and also another one, depending upon the variation of volume of the liquid, as will be explained farther on. This second set of values is the one referred to in each case in the preceding parts of this paper. None of these corrections are excessive. The first mentioned are so small as to be negligible in the molecular-weight determinations, and the second are not large. According to Landolt and Boernstein, a change of 1 mm. in the height of the barometer causes an appreciable change in the boiling-point of pure water (0.037°), and a change of 1° in the temperature of the barometer produces a change of 0.12 mm. in its readings, between the limits of temperature and pressure observed in this work. The maximum variation of barometer and of room temperature during each set of readings is given at the head of the corresponding table. The molecular-weight determinations were made without using the platinum cylinder.

I have confirmed the observations of Franklin and Kraus, that the boiling-point of the liquid in the tube increased with the amount of liquid present. To ascertain the volume correction, three determinations of the variation of the boiling-point of pure water with the amount of water (see tables C, D, and E) were taken without the platinum cylinder, and two with it (see tables F and G), besides several preliminary determinations. The separate determinations for the same condition are consistent with one another, as will be seen by comparing tables C, D and E with one another, and F with G.

This rise in the boiling-point of a solvent with increasing depth is obviously the effect of the weight of the upper layers of liquid in increasing the temperature of equilibrium between the liquid and vapor phases in the liquid surrounding the thermometer bulb. The rise in pressure due to an increase in the height of water in the tube of one centimeter would raise the boiling-point of the liquid surrounding the thermometer bulb by 0.027°, on the assumption that no mixing of the lower, hotter layers with the upper, cooler ones takes place. In practice, of

course, mixing takes place, with the result that an increase in the height of liquid, while not producing this maximum effect, still brings about a marked rise in the reading of the thermometer.

It was assumed that the volume correction would be the same for a solution as for pure water, which cannot be strictly true if the weight of the supernatant liquid has any influence. It was found that the boiling-point correction due to variable volume is practically negligible in the case of urea, and made a difference of from 1 to 3 per cent. only in the case of sugar. In tables C to E, inclusive, all the corrections mentioned in a preceding paragraph have been applied to the "boiling-point elevations" to give the "corrected elevations." The corrected elevations are the ones used in constructing curves. Tables C and G are taken as typical for the construction of curves (see plate VI).

TABLE C.—WATER.

Barometric variation, .76 mm.
Variation of room temperature, 1.1°.

Amount of water.	Boiling-point elevation.	Corrected elevation.
9.15 c.c.	.000°	.000°
11.25	.000	.004
13.84	.005	.009
16.29	.011	.019
19.53	.004	.015
22.16	.006	.019
25.42	.015	.026
28.58	.024	.038
32.39	.037	.051
35.90	.052	.071
39.33	.062	.080
41.93	.061	.089

TABLE D.—WATER

Barometric variation, .34 mm.
Variation of room temperature, .9°.

Amount of water.	Boiling-point elevation.	Corrected elevation.
9.70 c.c.	.000°	.000°
13.01	.011	.005
16.02	.019	.013
19.40	.024	.016
22.64	.035	.028
25.87	.040	.033
29.11	.051	.040
32.55	.053	.050
36.09	.071	.073

TABLE E.—WATER.

Barometric variation, .72 mm.
Variation of room temperature, 1.5°.

Amount of water.	Boiling-point elevation.	Corrected elevation.
9.86 c.c.	.000°	.000°
13.08	.000	.004
16.13	.001	.012
19.57	.005	.016
22.62	.007	.025
26.10	.013	.034
29.39	.017	.041
32.73	.033	.060
35.89	.041	.067
40.05	.064	.089
43.73	.073	.096

TABLE F.—WATER.

Barometric variation, .44 mm.
Variation of room temperature, 1.7°.

Amount of water.	Boiling-point elevation.	Corrected elevation.
9.63 c.c.	.000°	.000°
12.77	.009	.010
15.52	.019	.028
18.41	.019	.022
21.60	.029	.034
25.03	.044	.054
28.05	.058	.064
31.55	.072	.086
35.09	.088	.102
38.63	.100	.101
42.33	.117	.134

TABLE G.—WATER.

Barometric variation, .50 mm.
Variation of room temperature, 2.1°.

Amount of water.	Boiling point elevation.	Corrected elevation.
9.74 c.c.	.000°	.000°
12.69	.012	.010
15.43	.027	.028
18.86	.023	.031
22.05	.031	.045
25.17	.037	.051
28.27	.051	.065
31.42	.074	.085
34.63	.100	.104
37.69	.121	.120
40.75	.136	.132

TABLE H.—CANE SUGAR.

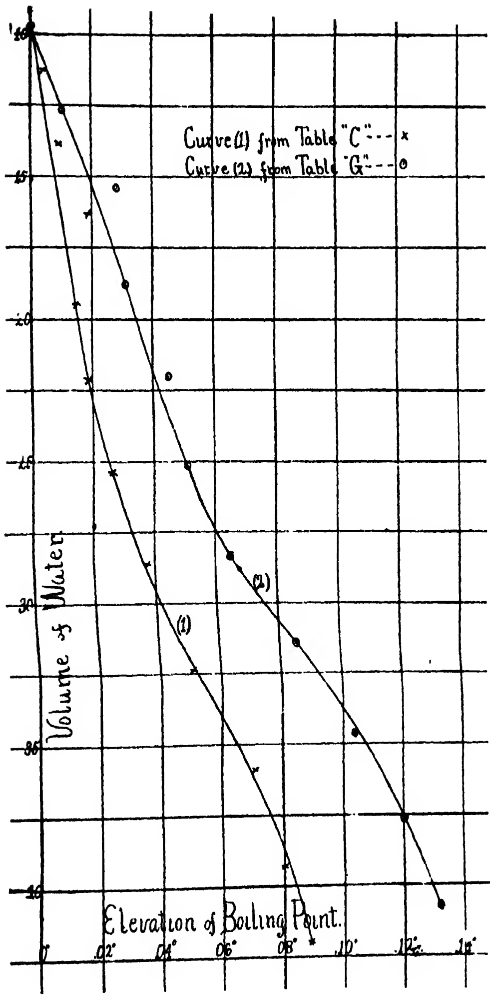
Amount of sugar in one liter of water.	Increase of solution in volume.
75 g.	2.5 %
260	14.8
383	21.8
471	27.4
536	32.0
589	35.1
630	38.0
664	40.0
692	41.8
697	42.3

It was found by trial that the volume of a sugar-water solution varies uniformly with concentration, up to an increase of 42.3 per cent. for a concentration of 14 g. of sugar in 20 c.c. of water (700 g. per liter; see table II). In the case of urea, 5.4 g. in 20 c.c. causes an increase of 19.6 per cent. in the volume.

Column 5, tables A and B, is obtained from column 4 by subtracting from each elevation the elevation due to increase of volume as ascertained from curve 2 and from a straight-line curve showing the increase of volume with concentration, which is obtained from data in the preceding paragraph.

The question of the effect of variation of length, shape and size of the tube, and of the nature of the liquid used, upon the elevation of temperature with increase in amount of liquid, is one that the author expects to take up in the near future. Only one tube has been available as yet, and only one solvent has been used.

PLATE VI.


Curve (1) from Table "C" - - - x
Curve (2) from Table "G" - - - o
Volume of Water.
Elevation of Boiling Point.
10
15
20
25
30
35
40
(1)
(2)
0
.02°
.04°
.06°
.08°
.10°
.12°
.14°

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CONTENTS:

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ON THE MOUTH-PARTS OF THE HEMIPTERA.

BY WALTER J. MEEK.

With plates VII, VIII, IX, X, and XI.

THE general structure of the hemipterous mouth was known to Savigny, but only in recent years has detailed work on the subject been attempted. In 1883 Otto Geise* presented a paper on the mouth-parts of some Hydrocorisæ, and in 1885 Herman Wedde published a similar one on the Geocorisæ. Two years later Leon studied the mouth of *Pentatoma*. In 1902 Smith advanced an explanation for the morphology of the hemipterous mouth, and later these views were commented upon by Marlatt. Heymons, in 1899, wrote on the morphological history of the Hemiptera.

Geise in his work discusses and illustrates clearly the mouth-parts of *Notonecta glauca*, *Nepa cinerea*, and *Corixa striata*. He advances nothing new as to the morphology of the parts. The pharynx or "Schlundkopf" and the "Wanzenspritze," which we shall term the salivary injector, are carefully discussed. The pharynx is composed of the well-developed epipharyngeal and hypopharyngeal lamellæ. The latter is greatly modified, having many cutting and grinding processes, evidently used in preparing the food. The muscles that raise the epipharynx are arranged in groups. The structure of the injector is more nearly constant in the three forms than that of any other organ.

For his investigations Wedde selected *Pyrrocoris apterus*. He describes the pharynx as being a simple unmodified tube. It is supported and fastened to the head walls by a complicated

* For this and the following references, see bibliography at the end of this article.

chitinous structure, which Geise does not find in his specimens. The injector is very much the same as described by Geise.

Leon uses *Pentatoma* as the subject of his investigations, and, in a great measure, reproduces the work of Geise. The most interesting part of his paper is his discussion of the morphology. He considers the maxillary palpus as having disappeared with the maxilla's change of function. On one of the Tingitidæ from Ceylon he finds vestigial three-segmented labial palpi. He presents this fact as an argument for the belief that the labial palpi are lost in the Hemiptera, and that the labium is, therefore, composed of the submentum, mentum and glossæ and paraglossæ fused to form the terminal segments.

The *Cicada* nymph was used by Smith in his investigations. His explanation of the mouth-parts is, in brief, the following: The anterior sclerite on the cephalic aspect of the head is the labrum. Just behind the labrum is the mandibular sclerite, which is the true mandible. The maxilla is represented by the two stylets arising from one base, to which is attached the vestigial maxillary palpus, and by the sheath, usually recognized as the labium. The bristles represent the lacinia and the stipes of the maxilla, according to his work. The development has been the same as in the case of the Diptera. The basal joint of the beak is the cardo; the second segment the subgalea, and the third and fourth the two joints of the galea. All that remains of the labium is the mentum, a boat-shaped process lying between the stylets.

Smith's homologies seem to be fanciful. He apparently felt determined to make the changes in the mouth-parts correspond to those already found in the Diptera. In his dissections he seems to have overlooked the fact that the stylets do not arise from one base. Had he observed this, it would have been evident to him that his theory would not hold good. The boat-shaped process which he names the mentum will be recognized as the pharynx. Smith's paper has been severely criticized by Marlatt. Marlatt gives Smith well-deserved credit for calling attention to the mandibular and maxillary sclerites, but at the same time he refuses to accept the explanation of the morphologies.

The morphological development of the Hemiptera has been investigated by Heymons (1899). It is gratifying to know that

the morphologies advanced by him agree in the main with those held by earlier investigators.

It will be seen that, in Hemiptera, the Heteroptera have been the subject of most frequent investigation. The Germans, who have done by far the best work along this line, used these forms almost exclusively. For this reason the suborder Homoptera has been selected, and the purpose of this paper will be to give the detailed structure of the homopterous mouth as shown in one of the Cicadidæ and to compare it with the buccal structures of the Heteroptera.

The seventeen-year locust, *Cicada septemdecim*, on account of its large size and its abundance at certain periods, has been chosen as the type for study. The specimens were collected during their last appearance in this vicinity, May, 1895, by L. L. Dyche, at Lakeview, and by R. G. Gowell, at Linwood. This material was thrown into 95 per cent. alcohol, where it has since remained. The cicadas have been well preserved for anatomical study, especially the chitinous and muscular structures.

TECHNIQUE.

In order to study the structure of the head, coarse dissections were first made with the needle and knife, and then finer ones with the microtome. The first method, of course, needs no explanation, only it may be remarked here that it is an exceedingly valuable way to work out the orientation of the parts.

Great care is necessary in preparing specimens for the microtome, and also in staining and mounting the sections. The hard, brittle chitin makes it impossible to secure sections without first softening the chitinous parts. This may be accomplished by soaking the head from ten to twelve hours in a solution of Eau de Labarraque, consisting of one part Labarraque to six parts water. With a solution of this strength the muscular structure will be very slightly injured, if at all. From the Labarraque carry the specimen through various grades up into 95 per cent. alcohol.

For embedding, celloidin-paraffin methods have been used. Celloidin of any desired strength may be made by dissolving the well-dried celloidin in equal parts of ether and absolute alcohol. After the specimens have been properly dehydrated they were removed to the 4-per-cent. celloidin solution. *Cicada* heads were left for at least ten days or even longer.

Some satisfactory slides have been made from heads which remained in celloidin for three months. Instead of transferring the specimens to thicker solutions, it is easier and just as well to let the 4-per-cent. solution gradually thicken by evaporation. When the celloidin has reached a jelly-like consistency, the heads were removed and hardened in chloroform. On entering the chloroform the celloidin will usually turn opaque, but this condition disappears as the hardening process is completed. When the specimens are hardened, usually from one to several hours, they may be placed in the paraffin bath, and in another hour they are ready to be molded into blocks of paraffin. The specimens may now be kept indefinitely.

The above method is entirely satisfactory, but it is long and cumbrous. The Gilson process described by Lee is much more expeditious. The object is dehydrated, soaked in ether, and put in a test-tube with a thin solution of celloidin. The tube is then dipped into the paraffin bath and the solution boiled down to about one-third of its volume. The mass is then turned out and hardened for several hours in a mixture of equal parts of chloroform and cedar-wood oil. The specimens may now be molded into blocks of paraffin as before. The best results are obtained by dry cutting.

For staining, Delafield's hæmatoxylin and picric acid have been found most useful. The hæmatoxylin is a good nuclear stain, while the picric acid is a valuable secondary stain for distinguishing chitin. In staining, the usual method of procedure is followed. The sections may be cleared in cedar-wood oil or other clearer and mounted in balsam.

NOMENCLATURE.

The nomenclature of the insect head has been based on anatomical work entirely, and for that reason it has little morphological value. Some of the primitive sclerites are indistinct, while others have developed greatly. The result is that a given named area may include several sclerites or perhaps only a portion of one. This nomenclature, however, is sufficient for the description of parts, and when supplemented with explanations it will serve for morphological work. All terms denoting location of parts are used with the head in the feeding position. The beak is then at right angles to the body line.

EXTERNAL AREAS OF THE HEAD.

The general appearance of the *Cicada* head is familiar to most students. It is an isosceles triangle in shape. The vertex of the head marks the base, and at the basal angles are the large compound eyes. From the lower angle extends the slender, three-jointed beak or proboscis. From the cephalic aspect, the most prominent part of the head is the swollen, deeply furrowed frons. Beneath it is the smaller, roof-like clypeus. Laterad of both frons and clypeus lie the crescent-shaped loræ or mandibular sclerites. Still laterad of these lie the narrow maxillary sclerites. From the vertex to the tip of the beak the head averages 10 mm. in length, and from eye to eye it averages 7.5 mm.

THE EPICRANIUM.—(Fig. 1, *e*.) In generalized insects the dorsal surface of the head is marked by a well-defined Y-shaped epicranial suture. The sclerites lying back of the arms of the letter and adjoining the stem form an area known as the epicranium. Such an area (fig. 1, *e*) is easily observed in the *Cicada*, but the suture is T-shaped. The cephalic part of the epicranium is called the vertex, and this bears the three ocelli.

THE FRONS.—(Fig. 1, *f*.) Between the epicranial suture and the beak are three sclerites. The first of these and also the largest, a convex shield in shape, occupies the middle part of the cephalic aspect of the head, and is named the frons. The sclerite is protruding, with a deep wrinkle or fold along the median line. On each side, running laterad, are series of furrows, usually eight in number. The lower edge of the frons is narrower than the upper, and the junction with the clypeus is made in a curved line.

THE CLYPEUS. (Fig. 1, *c*.) The clypeus is the intermediate of the three cephalic sclerites. It resembles the frons in shape, but is considerably smaller in size. The elevation along the median line continues as in the sclerite above. The deep median sulcus, however, which is so characteristic of the frons, is not present.

THE MANDIBULAR SCLERITES. (Fig. 1, *mds*.) These have already been mentioned as lying laterad of both the frons and clypeus. They are crescent-shaped, sparsely covered with long hair, and are closely applied to the sides of the head. Dorsad

they meet the genæ. Their outer margins meet the maxillary sclerites, and their mesal sides are bounded by the frons and clypeus. The sclerite extends downward for half the length of the clypeus.

THE MAXILLARY SCLERITES. (Fig. 1, *mxs.*) Laterad of the mandibular sclerites are the long, narrow chitinized strips forming the lower lateral edges of the head. These are the maxillary sclerites. Viewed caudad they are much wider and lighter in color. They form the boundary for the lower part of the occipital foramen. The lower part projects into a mesal pointed piece, the maxillary process (fig. 4, *procx*), which in the normal position covers the hypopharynx and is closely appressed to the stylets.

MOUTH-PARTS. Before proceeding to descriptions of the individual organs, it may be well to note the main features of the insect mouth and the modifications they have undergone in the orders of sucking insects. The mandibulate mouth consists of two pairs of laterally working, shear-like jaws, covered above by the labrum and closed below by the lower lip, the labium. The inner surface of the labrum is sometimes developed into the epipharynx. The labium also bears on its inner surface a well-developed ligula or hypopharynx.

In the suctorial mouth the four jaws have elongated and become setiform. The labrum has been greatly reduced and the labium has become a canal-shaped beak inclosing the setæ. These homologies were long ago determined by anatomists. Westwood says of the Hemiptera: "The mouth is of the promuscid construction, the labium or canal being occasionally greatly elongated and extending beneath the body, and is either three- or four-jointed. The four internal delicate setæ represent the mandibles and the maxillæ." It is very gratifying to know that recent embryological work is verifying these early homologies.

THE LABIUM. (Figs. 1 and 2.) The most prominent of the *Cicada* mouth-parts is the labium. Early investigators termed the organ haustellum, rostrum, promuscis, proboscis, Schnabel, or Rüssel, but in late years, since more attention has been given to homologies, the name labium has come into favor and it will doubtless remain. The labium, then, the most noticeable part of the suctorial mouth, projects from the lower angle of the

head, and when at rest lies between the coxæ of the thoracic legs. In cross-section it is elliptical in shape. Its entire length is about 5¾ mm. In many Hemiptera this beak is divided into four segments, but in the *Cicada* there are only three. Of these the distal segment, the longest, averages 3¼ mm.; the middle one, 1 mm.; and the proximal, 1¼ mm. Since each segment must bear muscles to move the ensuing segment, the first and second are larger in diameter than the third. The enlargement is on the lower side and the cephalic line continues unbroken to the tip.

A heavy membrane (fig. 2, *m*) attaches the labium to a chitinized collar of the thorax. It should be noticed that the labium seems to belong to the thorax rather than to the head. In separating the head from the body, the beak is frequently left behind, because the attachment there is stronger than that binding it to the head. In the same manner, but by a more delicate membrane, the labium is fastened to the hypopharynx, or, speaking more accurately, the hypopharynx, an outgrowth of the labial floor, is connected with the labium by a thin membrane. (Figs. 3, 4, and 14, *m*.)

The cephalic surface of the labium is folded inward longitudinally, so as to form a well-defined groove or canal. This incurved structure may be readily understood by referring to a cross-section (fig. 8). The edges of this canal are, at the basal segments, rather widely separated, but they gradually approach, and at the beginning of the distal segment they touch, forming a nearly perfect tube. From the proximal segment, the heavily chitinized floor of the canal differentiates from the connective membrane and extends upward as a free chitinized rod (fig. 2, *cr*) To this are attached the retractor and protractor muscles.

In the first segment and the proximal half of the second, the space between the edges of the labial canal is occupied by the epipharynx. The two organs are dovetailed tightly together. The outer surface of the epipharynx and the inner surface of the labial canal are both grooved, and fit into each other as shown in figure 9. This arrangement converts the canal at this point into a perfect tube. The epipharynx is flexible, and envelops the stylets, fitting closely around the maxillæ, and almost making an inner tube.

Fine hairs cover the surface of the labium and these increase

in size until at the tip they become stiff bristles. The distal segment is most strongly chitinized and the tip is blunt rather than acute. As in other forms, the lower side of the beak is marked along its median longitudinal line by a seam which is usually taken as evidence of a fusion of two maxillæ to form the one organ.

THE LABRUM. (Fig. 1.) In the *Cicada* the labrum is rudimentary. It may be seen as a minute triangular process, the apex projecting from the front margin of the clypeus into the opening made by the edges of the labial canal in the first segment. On dissection it is found to be about 3 mm. in length, with its under surface grooved and closely fitted to the underlying epipharnyx. With the change in the manner of securing food, the labrum of course became functionless. The only duty it could perform was to hold the stylets ir place, but for this the epipharnyx has become much better fitted. The result has been as one would expect: the labrum is greatly reduced and the epipharynx has become comparatively much more important.

THE EPIPHARYNX. (Fig. 7, *ep*.) This organ has necessarily been described in discussing the labrum. In the *Cicada* the epipharynx resembles the labrum and has usually been confounded with the latter by investigators. It originates from the lower inner lining of the clypeus, is canal-shaped, cross sections giving a crescent (fig. 9, *ep*) and projects farther forward than the labrum. It will be referred to more explicitly when the stylets are discussed.

CAUDAL VIEWS OF THE HEAD. (Figs. 3, 4, and 5.) Before proceeding farther in the study of any one organ of the mouth, it will be well carefully to examine the head from the caudal aspect. By removing the head from the body and then the labium from the head, figure 3 may be obtained. On the vertex two large muscles (fig. 3, *ml*), which fasten at one end just within the occipital foramen and at the other to the prothorax, are prominent. Below them is the head cavity filled with glands which cannot be studied here. Extending from one side to the other across the middle portion of the head is a thin chitinous band, the tentorium (fig. 3, *t*). The median portion is slightly thickened, and this is the tentorium proper. The tendonous strands connecting the median portion with the head wall are

the posterior arms, while those (fig. 3, *at*) which sink deep into the head are the anterior. The latter may be traced to the cephalic side of the head along the line where the mandibular sclerite and the frons meet.

Connecting with the head wall, at about the same place as the posterior arms of the tentorium, are the S-shaped cervical sclerites (fig. 3, *csc*). To these are attached a complex series of muscles (fig. 3, *cm*) which fasten in the prothorax. These sclerites, figured only on one side of the illustration, may be seen in the neck of the living specimen. They serve as fulcrums on which the head is turned.

Below the tentorium and converging toward the ventral median part of the head are two large, prominent muscles (fig. 3, *min*). These form perhaps the most noticeable part of the caudal aspect. Between them is a small duct which divides into two branches (fig. 3, *sd*). From chitinous plates lying at either side of these large muscles, and forming part of the head wall, spring other large muscles (fig. 3, *mr*) which give the head its rotary motion. At their ventral ends the converging muscles just mentioned pass under a funnel-shaped, thinly chitinized structure, the hypopharynx (fig. 3, *h*). This organ is an outgrowth of the inner surface of the labium, and its connection with the latter may be easily noticed at *m*, figures 3 and 4.

On the removal of the labium, stylets are found to be concealed in the labial canal. These at first tightly adhere to each other, but they may be separated. They are then four in number. The inner pair are the smaller and more difficult to separate. The stylets diverge at the tip of the hypopharynx and are lost to sight in the head itself.

Figure 4 is a caudal view, similar to the preceding, except that the muscles and flesh have all been removed. Two thin chitinous plates (fig. 4, *cp*) support the large, converging muscles. At their dorsal end these plates are united with the posterior arms of the tentorium, and the two structures are then both attached to the head wall. At their ventral ends the plates pass without interruption into the walls of the hypopharynx. Laterad of these plates are the caudal surfaces of the head wall which support the retractor muscles of the labium (fig. 4, *cmx*), as well as the rotary muscles of the head.

Occupying the median portion of the head, and running in a longitudinal direction, is the keel-shaped and strongly chitinized pharynx (fig. 4, *p*). Its ventral end curves upward into the head and disappears behind the hypopharynx; its dorsal end becomes less strongly chitinized and gradually assumes the character of the ordinary esophagus.

Closely appressed to the hypopharynx are the distal ends of the maxillary sclerites. These are shown slightly removed in the illustrations, but normally they lie close together, their edges meeting along the median line. Their inner edges are produced into palpus-like appendages (fig. 4, *procx*), termed the maxillary processes.

MANDIBLES AND MAXILLÆ.

When the labium was removed from the head several stylets were found in the labial canal, and these we are now ready to trace out. By taking away the chitinous plates and pulling the maxillary sclerite aside, a view will be obtained corresponding to the right half of figure 5.

The setæ first exposed to view are the smaller, inner ones, and from their caudal position we know that they are the maxillæ. The base of the stylet is enlarged and triangular in shape (fig. 5). From the mesal edge of this enlarged base there extends to the maxillary sclerite in the head wall a crescent-shaped sclerite (fig. 5, *ca*). The dorsal edge of the piece is notched, and from the projection a tendon reaches to the tentorium (fig. 5, *mc*).

The musculature of the maxillæ is not complicated. There are two retractors (fig. 5, *mxr*), both of which reach from the inner surface of the epicranium to the base of the maxillæ. One protractor (fig. 5, *mxp*) fastens to the crescent-shaped sclerite, and the other to the lateral edge of the caudal face of the maxillary base. Both of these muscles are attached to the inner surface of the maxillary sclerite.

Upon removing the maxillæ, the heavier, outer pair of the stylets will be found directly beneath, as shown in the left side of figure 5. The mandibular base is at first apparently shaped like the maxillary base, but the dorsal part extends into two processes, one much wider and larger than the other. To the mesal one of these is attached the mandibular retractor (fig. 5, *mdr*). This muscle has a threefold origin; the strands unite, however, and fasten to the mandible by a single tendon. The

protractor muscle (fig. 5, *mdp*) extends from the cephalic face of the mandible to the maxillary sclerite (fig. 5, *mds*). It is a single muscle, but well developed. A quadrangular sclerite (fig. 5, *co*) serves to connect the mandible with the head wall. The joints are simple hinges, and the point of attachment is the dorsal end of the mandibular sclerite.

Figure 6 shows the enlarged tips of the stylets. The mandibles are serrated on the outer edges, but the maxillæ are smooth and sword-like. While in position the tips of the maxillæ are straight, but when free from the enclosing mandibles they assume a slightly recurved position.

The relation of the stylets to each other and the surrounding parts can best be studied by means of cross-sections. Figure 8 is such a section through the third labial segment. The stylets are all crescent-shaped, and through the central portion pass lumina (fig. 8, *l*), which are somewhat larger in the mandibles than in the maxillæ. The concavity of the mandibles is so great that they are almost able to enclose the small inner setæ. Although the maxillæ are side by side as they leave the head, by the time the third labial segment is reached, one is directly above the other. The inner surface of the upper maxilla is twice grooved. The three projections thus produced are mortised into the lower maxilla. This dovetailing is nicely done, and accounts for the difficulty in separating the two smaller setæ. It will be noticed that this device makes two tight tubes, one somewhat larger than the other. Around both sets of stylets is folded the strongly chitinized labium with its upper edges very closely appressed.

Passing from the third labial segment toward the head, there is little change in arrangement or structure until the first segment is reached. At this point the stylets enter the enclosing epipharynx (fig. 9). To this organ they are rather securely fastened by a grooved contrivance. A well-defined groove passes down each side of the upper part of the epipharynx and into these fit projections from the closely lying mandibles (fig. 9, *mg*). The maxillæ are not shown in the figure, but it can be readily seen how they are held between the concave mandibles. The epipharynx is itself in turn similarly attached to the labial wall (fig. 9, *lg*). This arrangement of interlocked parts explains why the organs at this point are separated with so much

difficulty. Where the stylets are held so tightly together by the encircling epipharynx, the mandibles and maxillæ rapidly diverge and enlarge into the basal portions already described. The position of the bristles in the head may be illustrated by a capital letter Y. The stem is made up of the four stylets and lies in the labium; the arms are each composed of a mandible and a maxilla, and one lies on either side of the head.

THE PHARYNX.

We are now ready to return to the brown, keel-shaped structure already mentioned as occupying the median portion of the head, and figured in the caudal views (fig. 4, *p*). This is the organ so frequently referred to by German writers as the "Schlundkopf." When dissected out it is only about 2 mm. long, and hence is best studied by means of cross- and longitudinal sections.

Figure 13 is a cross-section made through the upper edge of the clypeus. The form and position of the pharynx are at once apparent. It consists of two troughs (fig. 13, *p* and *pc*), one lying within the other. The lower one, a continuation of the mandibular sclerite, is much more strongly chitinized than the upper. Its inner surface is slightly grooved. Its outer convex surface is the part that meets our view in the caudal aspect. The upper fold, which is continuous with the frons and clypeus, is much more delicate than the lower, but toward the edges where the two folds coalesce, it is strongly chitinized and exceedingly elastic.

A slight thickening (fig. 14, upper *p*), which evidently serves for purposes of attachment, marks the median portion of the upper fold. Figure 12 makes the function of this part clear. Tendons are attached to the median part, and as they extend upward muscles branch off on either side pinnately. These muscles are fastened to the inner surface of the frons.

To obtain a more correct idea of the pharynx and its position in the head, a median longitudinal section will be most helpful. Figure 14 gives such a view. The organ under discussion is crescent-shaped, with one end facing the clypeus (fig. 14, *c*) almost squarely, and the other extending to the middle portion of the head. The caudal part is tubular, but slightly chitinized, and has all the appearances of the esophagus, into which it passes on its backward course. Cephalad

the lower part is strongly chitinized, and, in connection with the upper, more delicate fold, forms the double-trough-shaped portion already described (fig. 13). This trough-like structure, to continue the homely figure, terminates cephalad by the lower fold suddenly turning upward and forming a prow. From the base of the prow a strongly chitinized tube leads downward and backward, and terminates at the caudal extremity of the epipharynx.

THE HYPOPHARNYX.

In dissecting the head from the caudal side, a funnel-shaped, chitinized organ (fig. 3, *h*) is found at the lower end of the pharynx. This is the hypopharynx. The funnel shape is closely preserved only in the caudal portion, for in front the organ is fused with the pharynx. On each side of the latter the hypopharyngeal lamella extends dorsad, as a thin, chitinized plate (fig. 4, *cp*). These plates serve as a support for the large diverging muscles (fig. 3, *m.in*) already mentioned. The hypopharynx completely hides the tubular, canal part of the pharynx. On its caudal rim the hypopharynx ceases to be chitinous. From this point the tissue continues as a fleshy fold (fig. 14, *m*) until it passes into the dorsal surface of the labium, where it is again chitinized. The funnel tube sinks into the head and terminates in a tongue-shaped piece at the same point as the conduit from the pharynx. This is the part usually referred to as the true hypopharynx. The lower parts of the chitinous plates just mentioned, near where they fuse with the pharynx (fig. 13, *mg*), are fitted with the usual grooves and projections for holding and supporting the maxillæ. This structure corresponds to the far more elaborate "Fuhrungsleisten" described by German writers. In the *Cicada* they show nothing of the double fold and canal shape described by Geise for the Heteroptera.

THE SALIVARY INJECTOR.

Even in the coarse dissections with the needle, it appears that there is a chitinized organ lying in the cavity between the hypopharyngeal structures and the pharynx. The large converging muscles so prominent in the caudal view (fig. 3, *m.in*) meet at this point. But little more can be determined without the aid of cross- and longitudinal sections. For this organ I propose

the name of salivary injector. The reasons for the choice will appear as the discussion proceeds.

From sections we learn that the injector is a chitinized cylinder, furnished with a plunger, inlet and outlet tubes, and valves. An idea of its structure may be obtained from figure 14. One of the retractor muscles (fig. 14, *m.in*) is shown, although, correctly, it should not be figured in a median longitudinal section. The cylinder is conical at the cephalic end, compressed in the middle, and invaginated at the back. The central portion of the invagination is strongly chitinized, and serves as the point of attachment for a tendon which divides and sends a part to each of the large muscles of the injector (fig. 3, *m.in*). The rim of the cylinder is connected with the invaginated part by strong, elastic chitin. The normal position of the injector is that given in figure 14.

Among the Heteroptera Geise noticed, in regard to shape, two types of the injector. The water forms were all slightly spherical, while the land forms were cylindrical. A suggestion offered by him to account for the difference is, that the latter form gives greater elasticity, which might be required by the land form in forcing saliva into woody tissue. If this be true, we should expect to find the cylindrical form among the cicadas, and such is the case.

In the ventral side of the cylinder the entrance for a duct may be found. A valve (fig. 14, *v*) guards the opening, with the tip of its flap pointing toward the cephalic end of the cylinder. From this entranceway a single duct leads backward. As it leaves the encircling hypopharynx it divides, and in the caudal view (fig. 3, *sd*) these divisions may be easily traced. They lead back to the glands which fill the rear and upper part of the head chamber.

The cephalic portion of the cylinder narrows into a dark, heavily chitinized tube with which the hypopharynx is fused. Shortly beyond the point where the hypopharynx fuses, the tube coalesces with the pharyngeal canal, and the two pass forward as the tongue-shaped structure already mentioned in the discussion of the hypopharynx. The true nature of the structure may now be understood. It is the organ referred to by Savigny as ligula or hypopharynx. It is formed, first, by a fusion of the hypopharynx with the outlet of the injector; and,

second, by the fusion of these parts with the canal from the pharynx. The canals themselves remain distinct and terminate at the distal end in delicate processes.

At the point where the fusions take place a horny ring is formed, and this Gerstfeld makes mention of in the following words:

"Vorn am Kopfe, fast in gleicher Höhe mit der nach aussen daran liegenden Basen der Mandibeln und etwas uber denselben Theilen der Maxillen sieht man, wie es scheint, bei allen Hemipteren ein horniges oder lederartiges Stück ein wenig vorragen, welches nach dem Vorgange Savigny's von allen Naturforschern als Zunge oder Hypopharynx gedeutet worden ist. Es bildet den untern Theil des vordern Randes eines mehr oder weniger kurzen, hornigen Ringes, welcher den Anfang des Verdauungkanales röhrenformig umgiebt und tiefer in den Kopf hineindringt als die Mundtheile."

Gerstfeld and Burmeister both agreed in considering this part as an enlargement of the beginning of the alimentary canal rather than a fusion of the epi- and hypopharynx. They were correct in not referring its origin to a fusion of the epi- and hypopharynx, but only partly correct in their other conclusion, since they knew nothing of the salivary injector and its outlet. It is necessary that the pharyngeal and the salivary canals be kept distinct. At the same time, it is equally necessary that they be brought as closely as possible together. The point where they are first bound together shows a natural enlargement. Beyond this point the two tubes are thin and delicate, and extend forward until they are entirely surrounded by the encircling maxillary canals, which, it will be remembered, are made by the grooves in the concave side of the maxillæ. The horny ring, then, is not formed by the epi- and hypopharynx uniting to make the beginning of the tubular pharynx, but it is caused by a junction of the canals from the salivary injector and the pharynx.

PHYSIOLOGY OF THE PARTS.

Having described each organ in detail, we are now ready to discuss their functions. Before doing this, in order to get an idea of the parts as a whole, it is desirable to trace the lamellæ invaginated to form the mouth-parts from the exterior surface

through all of their modifications to the esophagus. Figure 14 will be useful for such a purpose.

The lamella composing the frons passes into the clypeus (*c*), and then bends back on itself, forming the short, triangular labrum (*l*). By bending a second time on itself, the longer, similarly shaped epipharynx (*e*) is formed, with its under surface well grooved to hold the stylets together. The lamella then differentiates into the upper part of the pharyngeal canal (*pc*), next into the upper part of the pharynx itself, and lastly into the esophagus. The lower lamella first outlines the labium (lab_3, lab_2, *lab*, and *la*). It then passes back as the membraneous portion (*m*) to the chitinized hypopharynx (*h*), which fuses with the walls of the salivary canal (*sc*). The walls of the cana' enlarge into the injector (*s.in*). From the dorsal wall of the salivary canal the lamella continues first as the lower portion of the pharyngeal canal (*pc*), next as the lower fold of the pharynx, and lastly as the esophagus.

The Hemiptera have always been known as sucking insects, but the problem has been to find out how the food reached the esophagus. From the descriptions of the parts, one must have already noticed that two of the organs have the character of pumps. Such is the case, the pharynx being an efficient suction-pump, while the salivary injector is a good force-pump. Perhaps the action and relation of all the parts may best be given by the imaginary feeding of some insect.

The tip of the beak is fitted with a tuft of hairs, a fact which is good evidence that the labium does not enter the body furnishing the food. Papillæ are present at the tip, and these serve as organs of touch and taste. The proboscis is held firmly against the bark, and, guided and supported by this encircling organ, the mandibles begin to bore, cut and saw their way into the cortex of the plant. The serrations at the tips of the mandibles (fig. 6, *md*) are especially fitted for this class of work. Within the mandibles ply the maxillæ, which are able to pierce deeply with their sword-like points. That this is the action of the stylets may be proved by the position of the protractor and retractor muscles, which are arranged to allow only such movements.

As soon as this action is established the salivary injector comes into play. The retractor muscles of the injector con-

tract and pull the chitinized piston back. The valve at the lower side of the chamber opens and saliva from adjoining reservoirs fills the cavity. As the muscle relaxes the elastic chitinous wall resumes its normal position, the valve closes, and the saliva is forced down the salivary canal into the smaller maxillary tube, through which it reaches the food supply. That this action is possible has been demonstrated by actual experiment. Although the injector is exceedingly small, under a suitable microscope I have succeeded in watching the movement of the elastic parts as the muscle of the injector was pulled back and forth mechanically. In some of the Heteroptera, Geise describes a valve for closing the salivary canal while the saliva is being pumped in from the glands. Wedde does not figure such a structure, and I am unable to find it in the *Cicada*. It is probable that at that point the canal is thin enough to press together and serve as a valve. In any case the efficiency of the injector would scarcely be affected, for the secretion might easily be forced into the chamber by the pressure of the reservoirs in which it is contained after having been secreted by the salivary glands.

The saliva of the Hemiptera is alkaline, and has the power of changing starch to sugar. Plateau made this discovery by boiling four of the glands from two *Nepas* in starch. Glucose was found in the mixture as a product. Primarily, then, the saliva serves as a digestive fluid. The fact that it is forced to the end of the labium, instead of being mixed with the food somewhere in the digestive tract, goes to show that the secretion has other uses. It is undoubtedly forced into the puncture made by the insect in order to increase the flow of sap. It also probably serves as a lubricant for the closely fitting maxillæ, since they would need something of the kind, and no other secretion is present.

As soon as a good flow of sap is started, the pharyngeal muscles (fig. 12, *m*, *p*) contract. By the alternate lowering and raising of the upper fold of the pharynx, a suction-pump is produced, the pipe for which is the pharyngeal canal and the upper maxillary tube into which the canal extends. The lower part of the tubes formed by the inner concave surfaces of the maxillæ are probably not air-tight. Suction, then, would not be sufficient to raise the fluid the entire distance from the tip

of the beak to the pharynx. It is, therefore, probable that capillarity accounts for the fluid rising in the lower part of the stylets. The action of the pharynx is, however, the stronger and more important of the two. There is no arrangement to prevent the fluid from flowing back when the pharyngeal muscles relax. Such a device would not be absolutely necessary, since the esophagus is the larger of the two tubes, and most of the food would pass that way. It is also possible for the muscles at the front to relax first, thus closing the pharyngeal canal and forcing the liquid into the esophagus.

Leon and Geise each figures serrations and papillæ on the inner surfaces of the pharynx. They suggest that these are used in grinding any granular food that the insect may take. The *Cicada* certainly has none of these devices, and it would seem that they were scarcely necessary in suctorial insects. The upper lamella of the pharynx is coarser where the pharyngeal tendons are attached, but this is due only to the natural enlargement of that portion.

A word here concerning the feeding habits of the cicadas may not be amiss. Early students of these insects held that the adults feed but little, if at all. Some have insisted that the females, needing nourishment for the process of egg-laying, take nourishment, while the males never do. In support of this view, it was announced that the digestive tract of the males was rudimentary. Marlatt, in his excellent report on the periodical cicada, makes the following statement:

"Such feeding is limited, at any rate, to the females, as in this sex only do we find a perfect digestive apparatus."

Until recently most of the suggestions on the subject were general and not supported by actual investigations. In June 1902, it was reported to Quaintance that the cicadas were feeding on an orchard near College Park, Maryland. His investigations give us the first authentic information on the subject. (Quaintance, 1902, *a* and *b*.)

Both males and females feed during the adult stage. Some of the beaks were snipped off by scissors and photographs then made of the parts. As described above, the tip of the proboscis was found resting on the bark while the stylets had pierced the cortex. Quaintance immediately dissected the digestive

tracts and found those of the males as well developed as those of the females.

In brief, then, the cicadas do not differ in their feeding habits from other Homoptera. Both males and females feed. If confined, they soon die from lack of nourishment. Occasionally orchards suffer severely from loss of sap given up as food.

MORPHOLOGY.

The morphology of the hemipterous mouth-parts still remains uncertain. Various interpretations have been presented, but the only ones on which investigators agree seem to be these: The parts are appendages of the head segments. The inner stylets correspond to the maxillæ, the outer to the mandibles. The sheath is made up of the labium and labrum.

No one attempted to work out the subject from an embryological point of view until Heymons. His results are valuable. At an early stage the appendages of all the head segments appear. The size of the clypeus is especially remarkable. The labrum appears late. The second maxillæ, which later fuse and form the labium, seem to have a tendency to fuse with the thorax. This fact accounts for the characteristic position of the beak in all Homoptera. The first maxillæ soon divide into a medial and a lateral lobe, termed the *lobus internus* and *lobus externus*. The medial lobe, termed the "Lade," together with the mandible, soon become retort-shaped, and later develop into the maxillary and mandibular setæ. The latter portion, the "Maxillenhocker," extends backwards and gives rise to the maxillary sclerite. The maxillary process appears early in the embryo. The top of the head is formed by large lateral lobes, the "Kopflappen." The sides of the head owe their origin mostly to the lateral maxillary lobe. The loræ or mandibular sclerites are related to the mandibles in much the same way as maxillary sclerites are to the maxillæ, but their origin is not made clear.

All of this knowledge is valuable, but it is not yet complete. Such questions as "What part of the typical maxillæ do the setæ represent, what has become of the maxillary and labial palpi, and what parts of the second maxillæ have fused to form the labium?" are yet unanswered. Embryological work, supplemented by the anatomical, will probably solve the problem.

With the exception of figures 1, 2, and 4, the drawings for this

paper were prepared by the author and inked in by Miss Margaret Wise. The figures mentioned were made from wash-drawings by Miss Wise. In conclusion, the writer desires to thank Prof. S. J. Hunter for his kindness and help. Without his interest and inspiration the work would have been a far more difficult undertaking.

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EXPLANATION OF ABBREVIATIONS

REFERRING TO PLATES VII TO XI.

at..........Anterior arm of the tentorium.
c...........Clypeus.
ca.........Crescent shaped sclerite attached to the maxillæ.
co..........Hinge connecting the mandible with the head wall.
cr..........Chitinous rod differentiated from the cephalic surface of the labium.
cp.........(In figs. 4 and 13.) Chitinized plate for the attachment of the muscles belonging to the salivary injector.
cp.........(In figs. 11 and 14.) The chitinized plunger in the salivary injector.
cm.........Muscles attached to the cervical sclerite for moving the head.
cmx........Chitinized plates for attachment of the rotary muscles of the head.
csc.........Cervical sclerites.
e and *ep*....Epipharynx.
f...........Frons.
h...........Hypopharynx.
l...........Lumina.
la..........Labium.
lab (1 2 3)...First, second and third segments of labium.
lc..........Chitinized labial canal.
lp..........Labial protractor.
lr..... ....Labial retractor.
m..........Membrane connecting hypopharynx with labium.
mc.........Tendon connecting the crescent-shaped sclerite with tentorium.
md.........Mandible.
ml.........Muscles moving the entire head.
mr.........Rotary muscles of the head.
mg.........Process holding the maxillæ to the epipharynx and the chitinous plates.
mdp...... Mandibular protractor.
mdr........Mandibular retractor.
min........Muscles of the injector.
mds........Mandibular sclerite.
mx.........Maxilla.
mxp.......Maxillary protractor.
mxr........Maxillary retractor.
p...........Pharynx.
pc.........(In fig. 14.) The pharyngeal canal. In other figures, the lower lamella of the pharynx.
procx......Maxillary process.
s...........Stylets.
sc......... Salivary canal.
sd..........Division of salivary duct.
sin.........Salivary injector.
t...........Tentorium.
tl..........Tip of labium.
tp..........Tendons of the pharyngeal muscles.
tmx........Tip of maxilla.
v...........Valve in injector.
z...........Muscle for movement of head.

PLATE VII.

Fig. 1.—External cephalic aspect of the head.
Fig. 2.—Caudal view of the labium.

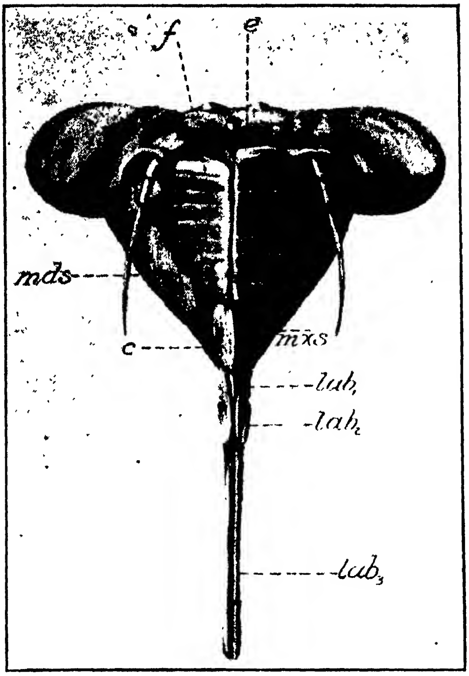


Fig. 1.

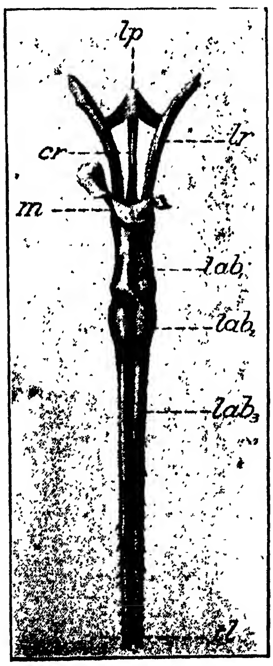


Fig. 2.

PLATE VIII.

FIG. 3.—Caudal view of the head as it appears when first removed from the body.

FIG. 4.—Caudal view of the head with the muscles removed to show chitinous structures.

FIG. 5.—Caudal view of the head with muscles and chitin removed to show the mandibles and maxillæ. A mandible with its attachments is shown on the left and a maxilla on the right.

FIG. 6.—Tips of mandibles and maxillæ.

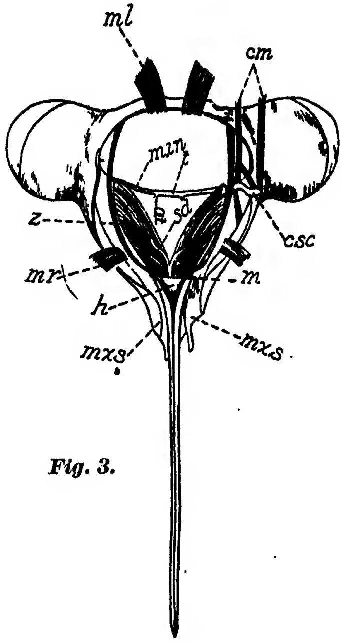
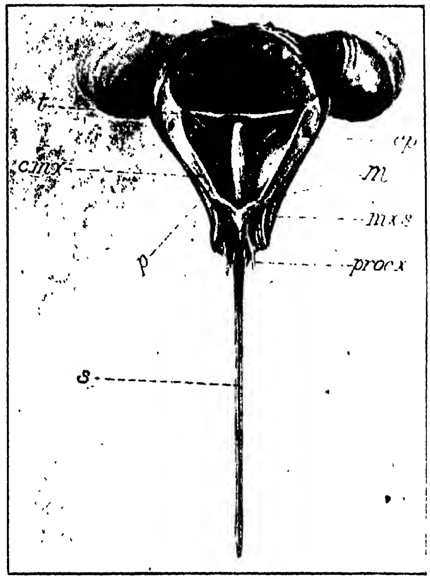


Fig. 3.

Fig. 4.



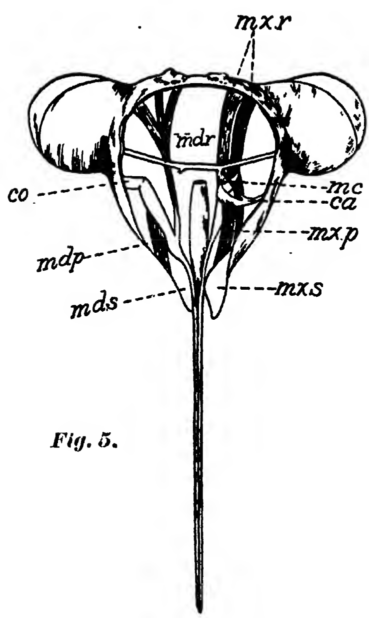


Fig. 5.

Fig. 6.

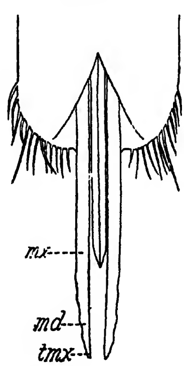


PLATE IX.

FIG. 7.—Under side of clypeus, showing closely lying structures.

FIG. 8.—Cross-section of labium. Third segment.

FIG. 9.—Cross-section through distal part of the clypeus.

FIG. 10.—Cross-section through proximal part of the clypeus.

PLATE IX.

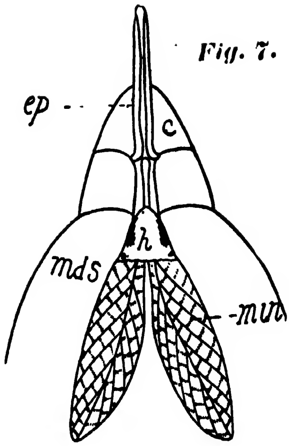


Fig. 7.

Fig. 8.

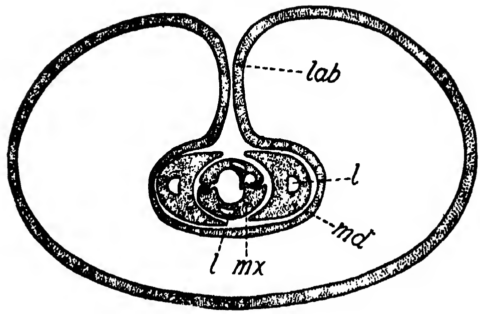


Fig. 9.

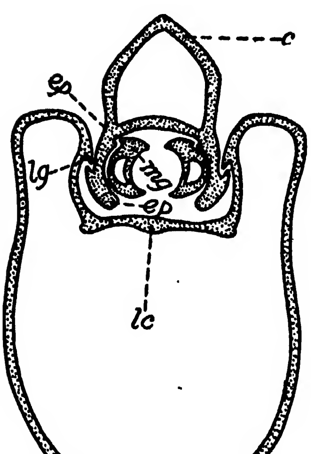


Fig. 10.

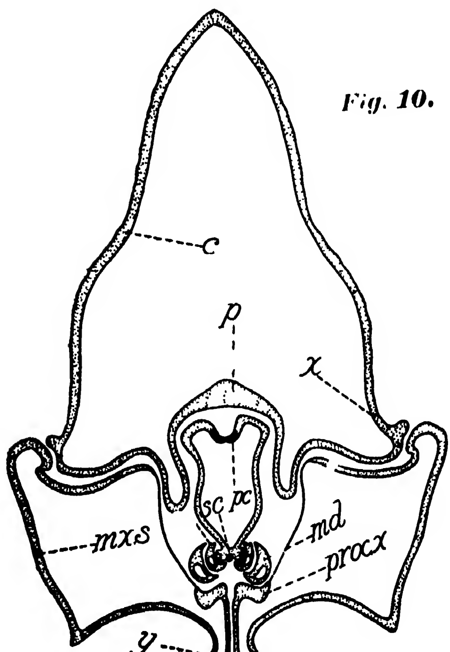


PLATE X.

Fig. 11.—Cross-section through the salivary injector.

Fig. 12.—Cross-section from epicranium to third labial segment.

PLATE X.

Fig. 11.

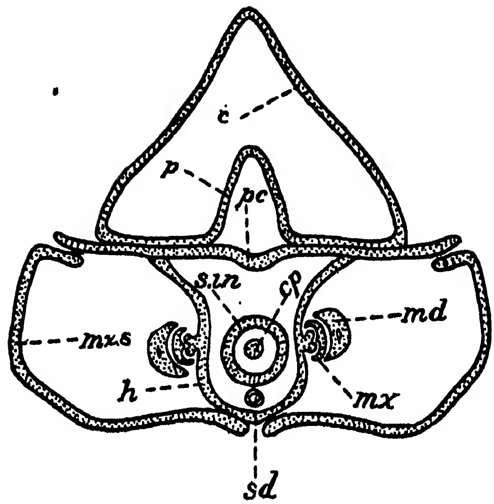


Fig. 12.

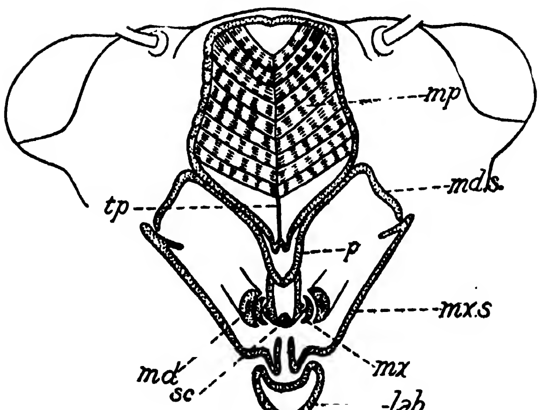


PLATE XI.

Fig. 13.—Cross-section through head caudad of the injector.
Fig. 14.—Median longitudinal section of entire head.

PLATE XI.

Fig. 13.

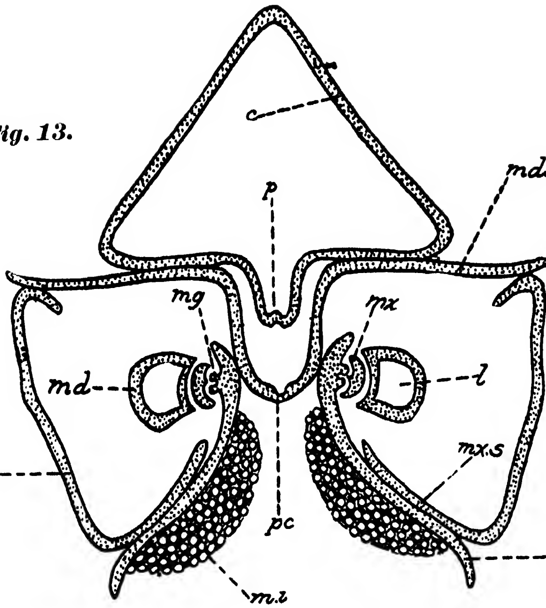
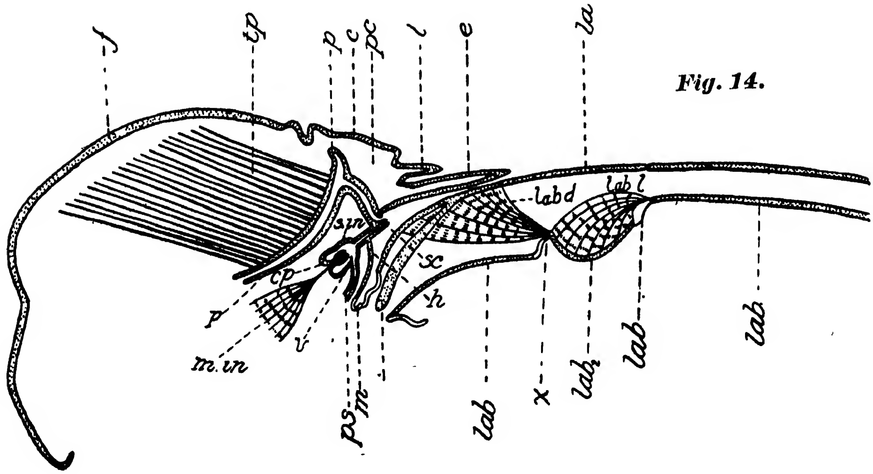


Fig. 14.



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THE VITELLINE BODY IN SPIDER EGGS.

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With plates XII to XV.

I. INTRODUCTION.

THE object of this work on the spider egg has been to gain some understanding of the peculiar element known as the vitelline body. Only those cell phenomena which in some way concern the origin, destiny and function of the body have been touched upon.

I want to express my thanks to Dr. C. E. McClung, who directed the work, and also to Mr. M. W. Blackman, for many helpful suggestions.

II. HISTORICAL STATEMENT.

There has been much confusion regarding the term "yolk nucleus." It has been applied to so many formations in the cytoplasm that its present meaning is very indefinite. Not only have we the one word applied to several different structures, but we are further embarrassed by having several different names for the same structure. Thus yolk-nucleus, corps vitellin, or vitelline body, and dotterkern are all applied to one structure by some writers, while sharp distinctions are made by others. The tendency now is to separate the terms, and call the peripheral globules, which collect in the early eggs just about the time of the yolk formation, yolk nuclei. Vitelline body is applied to the single large formation near the nucleus, arising also about the time of the collection of yolk.

The diffused yolk nuclei are of two kinds. Small bodies occurring very near the egg membrane, and staining densely, have been described by both Foot (4) and Calkins (2) in the earthworm. These occur in the egg of *Limulus*, as shown by Munson (6). The other diffused bodies lying in the cytoplasm, to which the term yolk nuclei has also been applied, are much larger than the peripheral formations, and lie scattered irregularly between the nucleus and the cell-wall. Calkins (2) in his work on *Lumbricus*, shows these bodies first collected in one mass around the nucleus, and later break up into separate spheres. They are homogeneous, and finally disintegrate, aiding in some way the yolk formation. Crampton (3) describes in *Molgula* a similar collection of material around the nucleus, and a subsequent breaking-up and scattering of the mass, though in this case the bodies are not so large or so definite as in *Lumbricus;* here the deutoplasm mingles more uniformly with the cytoplasm. We see, therefore, that while members of this class of yolk nuclei correspond to the peripheral ones in being many in number and in being scattered, still their origin is apparently different. The peripheral bodies certainly seem to arise in the cytoplasm ; at least, they are not a direct product of the nucleus. The others appear first close against the nucleus, and, according to Calkins, are formed from a portion of the chromatin reticulum cast out by the nucleus.

The position first occupied by the latter sort of diffused yolk nuclei would connect them with another class, the third and last of the deutoplasmic formations in the egg-cell. This is the single body which first arises as a crescent closely applied to the nucleus and later moves out from this membrane, becoming spherical in shape. Von Wittich was the first to investigate this body. In 1845 he observed it in the spider egg, and made a careful study of it in *Tegeneria domestica*. Balbiani (1) has perhaps done more work on this structure than any other one man. He made investigations upon both spider and myriapod eggs and found similar structures in them. In his paper "Centrosome et Dotterkern" he compares and identifies the two bodies.

He believed the yolk nucleus or "noyau vitellin" contained at its center the centrosome. In *Geophilus* (1) he found distinct radiations from that body which convinced him of the nature of the central sphere. In the spider he found no radiations, but the two formations agreed in other respects, and he concluded that in this class of animals, too, the yolk nucleus or vitelline body holds the centrosome. Munson (6) has described in much detail the egg of *Limulus*. He finds, also, the vitelline body there and compares it with that in *Geophilus*. Its position against the nuclear membrane, its striated outer wall, and its radiations are all similar. Munson believes the vitelline body of *Limulus* contains a centrosome.

The diffused yolk nuclei have been found by Jordan in amphibian eggs. Both the diffused and the single body, or vitelline body of Balbiani, have been found in mammals and birds (Mertens, 7), and in *Limulus* (Munson, 6). Whether these two apparently different classes of formations are essentially the same is a question to be solved by further investigation and comparison of different forms. The origin of the large vitelline body, as well as its fate, has been so variously given that nothing certain can be deduced. Largely for this reason its exact mission is unknown. Some have given it a very prominent place in the cell, believing it to be coordinate with the nucleus. Henneguy (5) compares it to the macronucleus of the Infusoria.

III. NOMENCLATURE.

The body found in the spider egg corresponds to the large single one in *Geophilus* and *Limulus*. For this reason I shall use the term *vitelline body* to designate it, and vitelline globules for the peripheral or scattered masses of yolk.

IV. MATERIAL AND MEANS OF COLLECTING.

Spiders are numerous and their eggs are still more so; for this reason I have been fortunate in not being limited in quantity of material. The early appearance of these animals in the spring and late disappearance in the fall is another advantage, as well as their habit of laying three or four times during the year. By or before the middle of March they may be found by turning up stones and old logs or by breaking off the loose bark of trees. The first warm days bring them out in great numbers. For my work, however, I could not go about picking them up indiscriminately, for some of the families do not have their eggs characterized by the vitelline body. The Agelenidæ, fast runners, but very handy to collect on account of their great numbers and showy homes, are among those without the structure. These spiders build the snowy, sheet-like web, so conspicuous on lawns and hedges, which possesses a tube, or funnel, through which the spider makes its retreat. Such spiders can be captured easily, however, by following down the tube, which is deceivingly short and frail at the bottom, and the captive makes little effort to escape when the tube is destroyed. Though these spiders have not the vitelline body, they are valuable for studying the form of the ovary; and in addition the eggs show the behavior of yolk free from the possible influence of a vitelline body. Their eggs are whitish in color, and possess a thinner membrane than those of the Lycosids, which is a favorable condition for fixation and embedding.

The Epeiridæ, that brilliantly colored family of orb-weavers, are, like the Agalenidæ, without the structure I sought. For this reason my study has been confined to two other families—Therididæ and Lycosidæ.

Therodion is the small, light brown or tan-colored spider

found so abundantly in cellars and other dark places. Members of this genus build irregular webs, and are convenient for collecting, since they can be found at nearly all times. They disappear very suddenly, however, when they realize an enemy is near; so I resorted to a means for their capture which proved successful in every case. By striking them slightly with the hard surface of the collecting bottle they drop from their webs upon the ground and feign death. There they lie with their legs drawn up about them, looking so nearly like a clod of dirt that one has difficulty in distinguishing them. They can easily be picked up from this position and placed in a bottle.

An important thing in collecting spiders is to have plenty of bottles or other receptacles for them. They are true cannibals, and should you place two together you will find but one in a short time.

My investigations have been made mainly on *Lycosæ*. These, on account of their great size and early appearance in spring, are especially desirable. The interest, too, attached to collecting them has perhaps caused me to use them. They are the very large, black, running spiders, inhabiting holes in the ground. They measure often one and one-half inches in body length and possess legs quite that long. Their mandibles are powerful and make no slight wound. They are, however, much more often on the defensive than the offensive, and I doubt exceedingly if they would attempt to do harm unless held or pained. They usually pull away from the enemy, even at the sacrifice of a leg.

Lycosa tegrina is the spider found about the University of Kansas. It makes its holes especially in the lower and flatter places, where vegetation is not too abundant and does not grow so tall as to hinder it running. I have found these holes most numerous where the land is low, moisture probably being a desired condition. The holes vary from an inch in diameter to one and a half or even two inches. They are from seven to nine inches deep, and do not, as some think, run straight down at right angles to the surface of the ground. I doubt if there is much uniformity in their methods or directions of digging, for those which I have examined have taken various turns. The main course is vertical, however. Often the opening runs obliquely for two inches and then turns downward. Classifica-

tion has at times been partially based on the manner of digging and the kind of hole dug, but it does not seem worthy of reliance. This species usually erects around the top of the hole a frail wall of web and grass.

Now as to the means for bringing the *Lycosidæ* from their holes something may be said. This is an easy matter if a little water be carried, and almost an impossibility without it. The water should be poured in slowly and allowed to run down the side of the hole. By this means the bottom begins to fill; as the water rises the spider climbs up to avoid getting wet, and soon appears at the top. If the water is suddenly poured in and strikes the inmate forcibly she becomes frightened and remains in the tube. Drowning her out is quite impossible, for it is well known how spiders can be submerged in water for days and still survive.

The males are easily distinguished from the females, not only because, as a rule, they have smaller bodies than the females of their species, and are usually more gaily colored, but because the male spider possesses attached to its head a pair of pedipalpi enlarged into bulbs at the ends. The female possesses pedipalpi, but no enlargement exists.

The greatest difficulty was experienced in obtaining the eggs in the maturation stages. This is because maturation takes place upon oviposition, and it is almost impossible to find them at just this time. For this reason, toward the close of March, I placed a large Lycosid in a glass jar half filled with well-packed earth. One day, so long after I had begun the experiment that I had decided it a failure, the animal began to dig near the center of the jar. When the hole was a half-inch deep she stopped removing the dirt and began to even the hole until it was very smooth with a gently curving bottom. Now she took a new position, with her feet on the edge of the opening and her body directly over it. From this position she lowered the abdomen until the spinnerets touched the center of the smooth surface beneath her and held them there for a short time. When she lifted the abdomen a small, shining patch of white was deposited on the ground and numerous silvery threads connected it with the spinnerets. This was the beginning of the cocoon.

From this time on she worked industriously. With a move-

ment as regular as clockwork the abdomen was raised and lowered—raised to unravel the threads, lowered and pressed firmly against the ground to fasten them. Never moving from the spot, but turning around and around over the hole, the little creature directed her spinnerets to every part of the bottom, until at last it was covered with a closely woven sheet. She was not content with the one layer, but spun another, and then touched it carefully here and there, to detect any neglected spots. When she found one, she spun diligently for some time about it, until it was completely remedied.

Then began the most interesting part of this queer performance. Placing the spinnerets at the edge of the white mat, she began once more a monotonous turning. So many times she turned and so empty the apparent result, I thought her insane from her previous work. After a long wait, I realized that a wall was growing, and although of such delicate and flimsy material, it was rising into space, unsupported by anything the eye could see. When completed, it was more remarkable still, for it leaned slightly over the hole, forming a sort of hollow sphere. A large opening was left at the top, however, and after a pause the spider ejected two drops of colorless fluid into the nest. These were soon followed by the eggs, which were a golden yellow, and so numerous and of such semifluid constituency that they were oviposited in a continuous stream. When the nest was almost filled, the little animal paused once more, then set about closing the opening. First she pressed the edges of the cocoon carefully over the eggs, but this not covering them, she began spinning once more. In a short time her treasures were sealed tightly within, and pressing the cocoon on all sides with the third pair of legs, she lifted it with the spinnerets and carried it to the edge of the jar.

V. TECHNICAL METHODS.

a. Fixation.

On account of physiological variations in the egg it was necessary to employ several fixatives. The very young ova are much more easily preserved than those further advanced; in fact, after the egg has entirely filled with yolk it is difficult to get a satisfactory fixation at all. The chief cause of the trouble lies in the egg-membrane. In the early follicular ova this is

very thin and delicate and is easily penetrated; but it increases in thickness as the cell grows, even adding in final stages new and separate layers, until days are sometimes required for the most penetrating fluid to reach the interior. Occasionally I succeeded in making an opening in the membrane by piercing it with a fine needle, but usually such attempts resulted in completely crushing the egg. One soon learns in working with such delicate material that the less it is handled the better. Even the force required to draw the eggs into a pipette will often break the membrane and allow the contents to flow out. To avoid these difficulties I left them in one vessel through the different processes, carefully drawing off the fluids from them and adding others. Even embedding was managed in this way: instead of lifting them from the clearing agent and placing them into melted paraffin, thus running the risk of crushing them at the very end of the process, I removed the fluid as completely as possible and then poured the paraffin upon them.

Of all the fixatives I used, Gilson's aceto-nitric sublimate mixture and Merkel's fluid proved most satisfactory. These came near working in all stages of the eggs' growth. Gilson's fluid was excellent for the oöcytes and even the mature egg, completely filled with yolk. The vitelline body shows at its best with this fixative, there being no shrinkage, and the material staining perfectly.

Merkel was used largely for the early stages, before the eggs had left the ovarian sac. The oögonia and young oöcytes are well preserved and stain readily with iron-hæmatoxylin. For this stage the Merkel fluid is better than Gilson, but those eggs in the follicle are not always successfully fixed. Passing this stage, however, Merkel works well once more; the mature egg is very well fixed by it, and also the segmenting egg.

Flemming has been used in preserving the ovary *in situ*, but not for a study of the finer structures.

Kleinberg's picro-sulphuric fixed the mature egg very well, but great care must be exercised in using it. If left in too long, the egg becomes greatly distorted and shrunken.

b. Stains.

Eggs fixed in Gilson and stained in Ehrlich's hæmatoxylin and acid fuchsin show the vitelline body very distinctly, but no radiations can be seen.

Lyons blue, with Gilson's fixation, makes a beautiful preparation. The eggs at all stages stain equally well with this. I have not found any stain which shows the vitelline body better. The yolk and cytoplasm take up the coloring, to be sure, but the vitelline body is much more deeply stained and stands out prominently. While the central sphere of the vitelline body is distinct, still the stain is not good for a study of fine structures.

For a study of mature eggs, Ehrlich's hæmatoxylin alone is very good. The yolk stains a uniform pale brown, while the nucleus and vitelline body are much deeper. The chromatic parts of the nucleus cannot be clearly distinguished, but the form of the nucleus at this stage can be seen. Younger eggs, even the oögonia, can be located clearly, but no careful study can be made.

Auerbach's stain, though the result varies with different conditions of the egg, differentiates the structures very well indeed. The young eggs color a delicate pink throughout. The yolk is yellow in those eggs where it has begun to accumulate; the nucleus and cytoplasm, pink. In other cases Auerbach stains all structures a purplish red, but even then the vitelline body is easily distinguished, because it is more densely stained.

Heidenhain's iron-hæmatoxylin is the best stain for detail work, as it brings out the most minute structures. Then the highest powers of the microscope can be used with this stain, while the diffuseness of the others makes such a thing almost impossible. For a study of karyokinesis I used it exclusively, and it did what the others failed to do; that is, it showed the pseudo-chromosomes, or small rods at the center of the vitelline body. It worked fairly well on mature eggs, but has the disadvantage of staining the yolk very densely, which in many cases cannot be bleached sufficiently for study. The thing most in its favor, however, is the uniformity with which it works, so that structures stained with it can readily be recognized at any stage of their development. While I used many other stains, I always verified my observations with this one.

VI. OVARY.

The ovaries of the spider are the most prominent organs of the abdomen. They lie completely embedded in a soft brown tissue, the so-called liver, more to the ventral than to the dorsal side of the body cavity. In the adult they extend from the anterior end of the abdomen to the posterior wall. As the eggs develop and increase in size, the ovary grows in thickness and width, until the entire abdomen becomes much enlarged. The liver grows proportionately thinner as this process continues. By a careful incision of the dorsal integument, and laying back the mass of liver, the numerous eggs may be seen. In *Lycosa* they are a rich yellow and very large, while in *Theridion* they are smaller and very white.

The ovaries thus filled with eggs have much the appearance of two bunches of grapes lying side by side. The entire mass is very soft, as the eggs have at this time no firm covering, but a most flexible and delicate membrane. Each ovary is connected at its anterior end with an oviduct, the ovaries themselves communicating at no point. Figure 1, plate XII, represents the posterior ends of two ovaries as they lie in the body cavity.

VII. OBSERVATIONS.

a. Development of the Ovary.

The reproductive organs of the spider differentiate at a very early period from the body cells, appearing first as two folds lying parallel to each other along the ventral aspect of the abdominal cavity. These assume a more definite shape as the animal grows, until there are soon two hollow cylindrical organs replacing the folds. The cells composing the ovaries at this early stage are apparently all alike, merely a mass of germinal epithelium surrounding a very small lumen. The outer wall consists of a layer of muscles, and between it and the epithelial lining lies a thin structureless membrane, the peritoneal coat, which cannot be distinguished until the follicles are formed.

So far the outer wall has a smooth surface, but very soon a change takes place on the interior of the tube which alters the appearance of the entire ovary. This change is as follows:

Certain groups of the cells lining the tube enlarge slightly and in time can be recognized as early oögonia. There are usually ten or twelve of the young germ-cells found clustered together, while around them the epithelium is unchanged. In one ovary such bunches may be very numerous. I shall not here describe the process in detail, but merely show how this change brings about the change in the form of the ovary. As these small germ-cells grow they push out through the muscular wall (Pl. XII, fig. 6), causing numerous diverticula on the outside of the tube. Projecting thus may be found oöcytes of nearly all ages, some very young, just pushing to the surface; others almost mature. By the time several generations of these cells have formed their follicles, the tube has become much distorted in shape. The walls in the old ovary are so convoluted that the lumen is difficult to distinguish. This is due to the great growth of the walls as well as to the distorting influence just mentioned.

For a study of the morphology of the ovary a young specimen is much better than an old one. The ovary has more rigidity at this time and is a straight tube, of which it is very easy to obtain a longitudinal section. A study of the organs *in situ* is perhaps more satisfactory than any other way, giving us best their relation to each other in the body. Fleming is very good as a fixative for this purpose, since it will penetrate even the tough outer covering of the body. The surest way is, however, to remove this covering before placing the fluid upon it. The fixative will then readily penetrate the tissue of the liver and will fix the ovary perfectly.

There is another advantage, too, in working with the young ovary. The ovarian cells and those in the follicles have not differed to any extent physiologically, and all come out equally well preserved. In the mature ovary, those eggs which have becme filled with yolk take the stains so differently from the younger eggs, especially the cells of the ovarian wall, that in preparation one set must be completely sacrificed for the other. It is almost impossible to make longisections of the distorted adult ovary. Cross and oblique sections quite as often occur, producing some very confusing images to one unacquainted with the structure of these organs.

b. Development of the Oöcytes.

The spots along the ovarian lining at which a conversion from epithelial into germ cells is taking plaçe can easily be distinguished. At such points there is a great thickening of the lining, or, we might say, a great multiplication of epithelial cells has taken place, until the new cells project far out into the lumen of the tube (Pl. XII, fig. 1, *c*, *d*, *e*), sometimes even filling the opening and crowding against the opposite wall. These cells, at their earliest stage, do not differ in appearance from the epithelial cells around them, unless it be in the nucleus, which seems to be slightly larger and richer in chromatin. The form of both, however, is much the same. Soon the nucleus increases in size until it almost fills the cell, the cytoplasm growing some, though not in proportion to the germinal vesicle. Out of the indefinite masses of chromatin a slender spireme is formed, which seems to consist of many long threads, crossing and winding among one another. At what appears to be the extremity of each thread is an enlargement which stains very densely. A close examination of these threads shows them to be made up of small segments, placed end to end. (Figs. 4, 5, 6, pl. XII.)

The stages between the spireme and the early oöcyte were clearly seen in ovaries fixed in Merkel's fluid, though much material collected was lacking entirely in cells at this stage. Lying embedded in the epithelial lining could be found division figures at all stages. (Pl. XII, fig. 2.) The chromosomes were distinct, but much crowded, so that, while I counted nineteen, I am by no means sure this is the actual number. The cells grow rapidly from this period, and their development is easily traced. They are always distinguishable by their clear appearance; large nuclei, with scattered patches of dimly stained chromatin, and cytoplasm, thin and lacking in reticular structure. (Fig. 7, pl. XII.)

Though in the early oögonial stages the developing germ-cells keep even pace, in their later development one gains decided advantage and grows much more rapidly than the others. We seldom find a group of oöcytes equally developed, but much more often we see one far advanced lying among many oögonia, probably in the spireme stage. It seems that natural selection has come into play, choosing one from the many

of equal age, and if not developing this one at the cost of the others, at least giving it much advantage in point of time. (Fig. 7, pl. XII.)

The location of the oöcyte changes as it grows, the cell moving more and more to the periphery of the tube, pushing through the epithelial lining, and finally through the muscular coat upon the exterior. (Fig. 6, pl. XII.) Its connection with the tube is not severed, however, for it has not broken the peritoneal coat. It has merely pushed this before it through the opening it has made in the muscular wall. Besides this means of preserving its relation to the ovary, it has a more efficient one still: a small mass of epithelial cells seems to follow in the track of the egg and to attach one point of its periphery. These cells are pulled partly out through the opening, causing them to appear as a neck holding the oöcyte in place. Their real mission is doubtless to convey nourishment from the interior of the ovary to the growing oöcyte, which needs such quantities at this period in its development.

The appearance of the nucleus during this progress does not materially change. While the oöcyte is in the tube the nucleus contains little chromatin, and this almost immediately begins to collect together. (Fig. 7, pl. XII). The cytoplasm is scanty and is scattered irregularly through the cell.

From this time the egg is most interesting in its development. The wall around it becomes thicker and firmer, yet does not lose its elasticity; for rapid growth takes place, enlarging and expanding constantly the outer membrane. The cytoplasm of the egg is no longer clear, but there seems to be an inpour of material clouding the cell and forming in certain parts of it a dense zone. There appears about this time, too, the peculiar element known as the vitelline body, the growth and development of which is unique. These things will be dealt with in detail later, so I merely mention them here.

As the cell grows the nucleus increases in size, becoming richer in chromatin. It possesses always one very large nucleolus, and very often three or four smaller bodies. The nucleolus is always vacuolated and the small bodies lying near have very much the appearance of being given off from it, as Balbiani described in his work on *Tegenaria*. Occasionally there may be seen inside the nucleolus very dense opaque bodies or

disks which do not stain, but lie bright and shining, refracting the light to a much greater degree than the surrounding structures. (Fig. 20, pl. XIV.)

c. The Vitelline body.

Up to the time when the oöcyte has left the ovarian sac, there is no trace of a vitelline-body; but the earliest follicular eggs contain what I take for the beginning of its formation. (Fig. 1, *g*, pl. XII.) Close against the nuclear membrane, and at one side, granules begin to collect, as if the cytoplasm were condensing at this point. The mass is at first scanty and extends only partially around the nucleus, forming a thin, crescent-shaped body; the granules are now very coarse and far apart. But as the crescent widens or increases in size the granules aggregate more closely, becoming quite dense at the point near the nuclear membrane where they first collected. Before this zone of dark granules has extended entirely around the nucleus, careful focusing will show a small sphere at its densest point. (Fig. 10, *a*, pl. XIII.) This appears to be a simple capsule; at least there are no concentric layers as seen lator. I am not certain of the internal structure of the body at this early age, but it is probably even at this time more complex than it appears, as I was able later, when the surrounding granules are less dense, to make out definite granules within. The usual appearance, however, and especially in its early stages, is a clear sphere, with a thin but well-defined surrounding membrane.

The crescent increases in size until its horns often meet on the opposite side of the nucleus (Fig. 11, pl. XIII.) This indicates an increasing amount of the granular deposit, which is doubtless a food material. As the mass thickens it forms into layers around the central sphere, the layers varying in number, width, and density. The number indicates to some extent the age of the body, the larger and consequently the older eggs having a greater number of rings than the smaller. (Fig. 12, pl. XIII.)

Fixations and stains have much to do with the appearance of the vitelline body; some obscure the concentric layers completely and cause the structure to look like a homogeneous mass. (Pl. XII, fig. 9.) Often, however, in the best-stained material the body varies, and I am inclined to believe that variations in appearance are not always due to stains and fixa-

tives, but frequently to the body itself. Very often when the concentrically striated wall is most distinct no central sphere can be seen, and there is a question in my mind whether it is always present. Merkel's fluid is best for showing the central sphere. Stained with iron-hæmatoxylin, it appears as a clear, transparent body with a definite outline, embedded in a homogeneous, densely staining mass, which is surrounded by a still denser ring. In some cases the sphere contains granules which stain much like chromatin. Again, in material fixed in Gilson may be found definite rod-shaped bodies in the central sphere of the vitelline body. (Pl. XIII, fig. 18.) Sometimes, when fixation has proceeded too far, the granules surrounding the central disk will draw together into more compact layers, thus separating slightly from the sphere and also from one another. There can then be seen a network of fibers throughout the vitelline substance, indicating that the latter simply lies embedded in the cytoplasmic reticulum. (Pl. XIII, fig. 12.) There is at times a suspicion of radially arranged fibers issuing from the central vesicle, but it is by no means distinct, and is probably no more than the network just described. (Fig. 26, pl. XIV.)

Later appearance of the vitelline body.—The vitelline body lies, first, closely applied to the nucleus, even at times indenting its wall. (Fig. 9, pl. XII.) As the dense zone around it clears up, the body moves out from the nucleus, and for a time gets farther and farther away. This is during the period of greatest cytoplasmic growth, and the separation of the two bodies seems to be influenced by it. Its distance from the germinal vesicle varies in different eggs, but usually, during the yolk formation, it lies near the periphery of the cell, separated from the nucleus by the entire radius of the cell. (Fig. 28, pl. XV.) The appearance of the body at this time is often peculiar. The central sphere is not distinguishable, and in many respects the body appears to be disintegrating. Figure 28, plate XV, shows the vitelline body lying near the periphery of the cell; the outline is definite on all sides but one, and here it fades into the cytoplasm, as if becoming a part of it. The body is no longer composed of concentric layers, but the granules which formerly constituted these seem to have formed into definite small, spherical bodies, much resembling the small globules of yolk, or

yolk nuclei of Foot and others, which are at this time forming at the periphery of the egg. These small masses, which stain a faded brown in iron-hæmatoxylin, are bursting from the broken wall of the vitelline body and are becoming scattered through the cytoplasm in that neighborhood. The material which showed this is some of the best preserved that I have, so it would not seem to be due to faulty action of the fixing agent. No central vesicle can be seen; the entire mass seems simply to be giving way and mingling with the cytoplasm.

Figure 29, plate XV, shows another appearance of the body in a late oöcyte. Here the concentric layers are disintegrating, only traces of them remaining. The contents have become coarsely granular and show a vacuolated or perforated condition. Figure 30, plate XV, exhibits the vitelline body of another egg, almost ready to leave the follicle. It is surrounded by yolk-spheres and cytoplasm. It shows, also, many vacuoles, and has much the appearance of a disintegrating body.

Had I stopped with these observations, I should certainly believe the body completes its mission as a food-producing organ thus early in the egg's history and then disappears. I am not sure but what it does this in some cases, as I can account in no other way for the appearance just described. It may be that the constitution of the egg differs enough to affect the persistence of such a body, causing it to disintegrate sooner in some than in others. However this may be, I found the body in other material, and in eggs much farther advanced than those just mentioned, still quite definite. Figure 31, plate XV, shows an egg entirely filled with yolk. The nucleus lies near the center of the cell, and very close beside it we see the vitelline body. The concentric layers are still present, though not as distinct as at first; the central vesicle is visible. The cytoplasm of the egg is reduced to the space immediately surrounding the vitelline body, and connects the latter with the nucleus. Iron-hæmatoxylin stains the yolk masses too densely to allow any structure to be distinguished. By much decolorizing the nucleus sometimes will give up the stain enough to become visible. The best stain for eggs at this stage, however, is Ehrlich's mixture.

We see, then, that the vitelline body, which has been widely separated from the nucleus, is once more drawing toward it, and at the time just previous to maturation. This seems to

favor the theory that the central clear vesicle is the centrosome, and approaches the nucleus preparatory to the maturation divisions. But let us follow the body further. We are able to trace it up to the time the nucleus breaks up for the maturation divisions, and, for a period, nothing is plain ; the great massing of yolk has obscured all other structures. It would be most interesting to be able to follow the vitelline body through this stage, though I am convinced it takes no part in division. This being a centrolecithal egg, the nucleus and scanty mass of cytoplasm surrounding it have moved to the periphery of the cell, and there divide, forming a layer of new cells just inside the old cell-wall. The yolk remains undisturbed at the center. The new cells formed by the first few divisions of the mother nucleus contain no trace of anything similar to the vitelline body ; that is, the embryonic cells do not possess the structure. But if we look carefully through the central mass of yolk we shall find the vitelline body almost as perfect as before maturation. This indicates that it played no part in the maturation processes, and especially not that of a centrosome.

Its disappearance varies ; usually it is gone before quite all the yolk globules are absorbed by the growing embryo.

d. The Vitelline Zone.

One of the most noticeable feature of many of these follicular eggs is the granular area, called by Balbiani the vitelline zone. In my material I find zones of two kinds. Always there appears the cloud around the nucleus previous to the vitelline body formation. This grows and spreads out considerably into the egg cytoplasm, usually remaining densest around the nuclear membrane, and gradually blends with the reticulum. The granules composing this zone, as a rule, stain more deeply than the cytoplasm, though I have sometimes found the very opposite true. The other zone is perhaps even more marked than this one. It is not found in all eggs, but chiefly in those of the young ovaries. The egg at this time appears to be composed of two parts, an inner sphere, filling about three-fourths of the egg, and an outer lamella. The former is of closely packed granules, with no reticular structure, and stains densely ; the latter is not greatly different, but is much clearer and thinner, with a suspicion of reticulum. There is no gradual blending

of these two zones, as in the crescent-shaped one first described. A definite wall separates the inner from the outer layer.

There is one feature of this zone that gives us, perhaps, the safest clue to its origin and composition. Plate XIV, figure 22, shows a section through the long axis of the egg and egg-stalk, and we see the inner zone extending into the epithelial cells of the stem, or, more according to my belief, rising from these epithelial cells. Now, this zone must be the food supply that is being constantly brought in by these nurse-cells in the egg-stalk, and deposited in the cytoplasmic network so compactly that the latter structure is made invisible. In the neighborhood of the vitelline body the mass stains more densely, showing a gathering of the metaplasm especially at this point.

The vitelline zone of Balbiani, or the dense cloud which collects about the vitelline body, and is especially prominent in the later stages of the follicular egg, has its origin also from the food material brought into the oöcyte by the nurse-cells, and is probably but a condensed form of the larger zone so conspicuous in the early eggs.

e. The Egg-stalk.

The above leads to a discussion of the function of those cells in the stalk of the follicular egg. We saw how the young oöcyte lay first among a group of growing oöcytes within the wall of the ovary. (Fig. 1, *e*, pl. XII.) For a time all remained equal in size; then, from some advantage which one or two gained over the others, they developed much more rapidly and completely outgrew them. As these increase in size they crowd through those around them, press up through the epithelial layer, and even separate the muscular covering, to pass through. The egg upon leaving the epithelial layer of cells comes in contact with the peritoneal membrane, which it cannot pierce; but the membrane, being flexible, is pressed before it through the muscular wall and there holds the egg in place. The epithelial cells, having been displaced, now move back and fill all space made by the departing oöcyte, shoving close against the lower wall of that cell. The arrangement of the cells would naturally be altered and they would no longer be so closely packed together, thus explaining the definite outline of the stem or yolk-stalk. (Fig. 1, pl. XII.)

These epithelial cells no doubt serve as nurse-cells to the follicular egg. The wall is not well defined around those oöcytes which have just pushed to the surface, and the nurse-cells press into their cytoplasm for some distance. (*G*, fig. 1.) We find this in still older eggs. Figure 16, plate XIII, shows the epithelial cells of the stalk lying in the cytoplasm of the oöcyte, entirely surrounded by it in some cases. Whether this is carried to a still greater degree and the cells absorbed by the cytoplasm, as has been suggested by some authors in other material, I cannot say, but figure 27, plate XIV, shows a gradual fading of these cells, which would indicate that some, at least, are being dissolved. As the egg grows toward maturity, and its food supply is about complete, a definite membrane forms between the neck and the contents of the egg. Figure 24, plate XIV, shows the complete formation of such a membrane, and also the reduced size of the stalk. The epithelial cells have, I believe, completed their mission, and the space which they occupy in the ovarian wall is assuming its former appearance. Figure 32 shows the neck about to disappear.

f. Eggs without the Vitelline Body.

Those eggs which do not contain the vitelline body present some differences. The cytoplasm of the young eggs contains much scattered food material. (Fig. 35, pl. XV.) Also the yolk formation begins much earlier than in eggs having the vitelline body.

VIII. SUMMARY AND INTERPRETATION.

The vitelline body makes its appearance first in the young oöcyte. After the last oögonial division the cell membrane is reconstructed, and for a time the cell grows rapidly. When it has attained a certain size it moves to the periphery of the tube preparatory to forming the follicle.

The oöcyte is occupied for a time in making its way through the ovarian wall. When it is at last upon the exterior, attached by a number of nurse-cells to the tube, a small crescent of darkly staining granules can be seen around the nucleus. At a slightly later stage a denser spot in the form of a tiny sphere can be observed in the midst of the granules.

Let us try to explain the phenomena thus far observed: the

dark zone, the denser spot at the center, and, finally, their appearance just at this time. The dark crescent is beyond doubt a collection of food material. Its origin may be, in part, from the nucleus, but mainly, we believe, from the substances brought in by the nurse-cells. Either the chemical composition of this material is such that it is not broken down directly and used, or more food-substance is furnished than the cell can utilize. As new supplies are constantly going in, the pressure becomes greater, and the granular mass grows more dense. Finally, close against the nuclear membrane at the widest portion of the crescent, and, consequently, at the point of greatest pressure, a spherical mass appears, the vitelline body. I believe the time of appearance of this structure depends upon the supply of food material to the cell.

The central clear vesicle is perhaps most perplexing. Balbiani (1) and Munson (6) believe it either to be, or to contain, the centrosome. The former regards it as a functionless centrosome of the female cell, but the latter considers it the centrosome of the dividing oögonia. True, its appearance is different from the surrounding layers of granules, yet it resembles so little a centrosome that appearance will not help us much in discovering its function. The best evidence that it is not the centrosome is its frequent absence, while all other parts of the structure are perfect. In such cases the central space is merely a loose collection of granules, like those of the concentric layers. This leads me to believe that this central clear vesicle is the result of great pressure of the metaplasm, which might bring about an extraction of certain constituents of the cytoplasm, and these, pushed thus to the center, form the central sphere of the vitelline body.

The body next moves from the nuclear membrane, which movement is probably due to increase of metaplasm between the two, or else to a growth of the cytoplasm.

Yolk now appears in the egg, usually about the periphery, in the form of "yolk-nuclei," described by Foot. In some cases the vitelline body seems to be disintegrating at this stage, breaking up directly into small globules of yolk. This early disappearance is another reason for believing it merely a food body. True, the surrounding metaplasm could disappear at this time and leave the central vesicle to perform its centro-

some function unencumbered; but it is a complete giving way, central vesicle and all.

The yolk, pressing more and more to the center, drives the nucleus and vitelline body inward, until we find them again close together, connected by the scanty remnant of cytoplasm which persists. Of course, this could take place only in those eggs where the vitelline body does not disintegrate, and, as a rule, the structure persists very long after this stage.

Just before maturation the nucleus moves to the periphery of the cell, leaving the vitelline body at the center. Here the nucleus divides, unaided in any way by the structure, which Munson believes to be the "centrosome of the growing oöcyte," and, lying undisturbed at the center of the cell, can be seen the vitelline body, even after numerous layers of cells have been formed. Balbiani found the body distinct in embryos two weeks old. The body fades when the yolk is about to be exhausted, or, we might say, is finally absorbed along with the yolk by the cells of the developing embryo.

This convinces me that the vitelline body contains no centrosome, but is merely a condensation of certain food-substances, which the protoplasm of the cells of certain spiders cannot immediately break down and use. Its absence in some families is due to those cells possessing engemes sufficient to dissolve these substances more rapidly.

More than this, structures identical with the central vesicle of the vitelline body have been found in eggs which at the same time possess perfectly distinct vitelline bodies. (Fig. 21, pl. XIV, and fig. 27.)

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X. PLATES AND EXPLANATION.

Drawings were made with a *camera lucida.* A Bausch & Lomb one-sixth-inch objective and one-inch eyepiece were used, except in figures 2, 6, 7, 8, 17, 29, where a one-twelfth-inch objective was employed. Occasionally a still greater magnification has been obtained with a one-half-inch eyepiece, viz., figures 3, 4, 5, 25, 32.

ZOOLOGICAL LABORATORY,
UNIVERSITY OF KANSAS,
June 1903.

PLATE XII.

Fig. 1.—A longitudinal section through the ovaries of a young *Lycosa*, showing the posterior ends of these organs as they lie in the body cavity. The ovary is a hollow cylinder lined with epithelial cells, *a*, and covered with a layer of muscular cells, *b*. At several points along the tube can be seen numerous cells projecting from the wall and almost, or quite, filling the lumen of the tube. These are the germ-cells which have differentiated from the epithelial lining; *c*, the very early oögonia, as yet scarcely differentiated; *d*, oögonia in the spireme stage; *e*, oögonia in the spireme stage and one oöcyte; *f*, follicular oöcytes, or those which have pushed through the wall upon the exterior of the tube.

Fig. 2.—Oögonia dividing to form the oöcytes. Though small and embedded in the cells of the ovarian wall, these division figures are easily distinguished by their clearness as compared with the granular appearance of the surrounding cells.

Figs. 3, 4, 5.—Greatly enlarged oögonia, showing the formation of the spireme.

Fig. 6.—A small portion of the ovarian wall, showing three oöcytes, *a*, pushing their way through the epithelial lining, *b*; *c*, a well-developed oöcyte upon exterior of ovary.

Fig. 7.—Portion of ovarian wall, showing muscle cells, *a*, and epithelial cells, *b*. Numerous oögonia, *c*, in the spireme stage surround the oöcyte, *d*. It is probable that this cell is no older than the sister cells among which it lies, but on account of some advantage in food supply has developed in advance of them.

Fig. 8.—Two oöcytes, *a* and *b*, lying against the ovarian wall, *c*, showing the relatively large size of the nucleus at this stage and its scattered masses of chromatin.

Fig. 9.—A follicular oöcyte, showing the large germinal vesicle, *a*, and the vitelline body, *b*, indenting its membrane. The fine granular area, *c*, is the vitelline zone in which lies much food material. The outer reticular area, *d*, is the cytoplasm. Comparing this figure with *f*, figure 1, we see the growth the egg makes as it nears maturity.

PLATE XII.

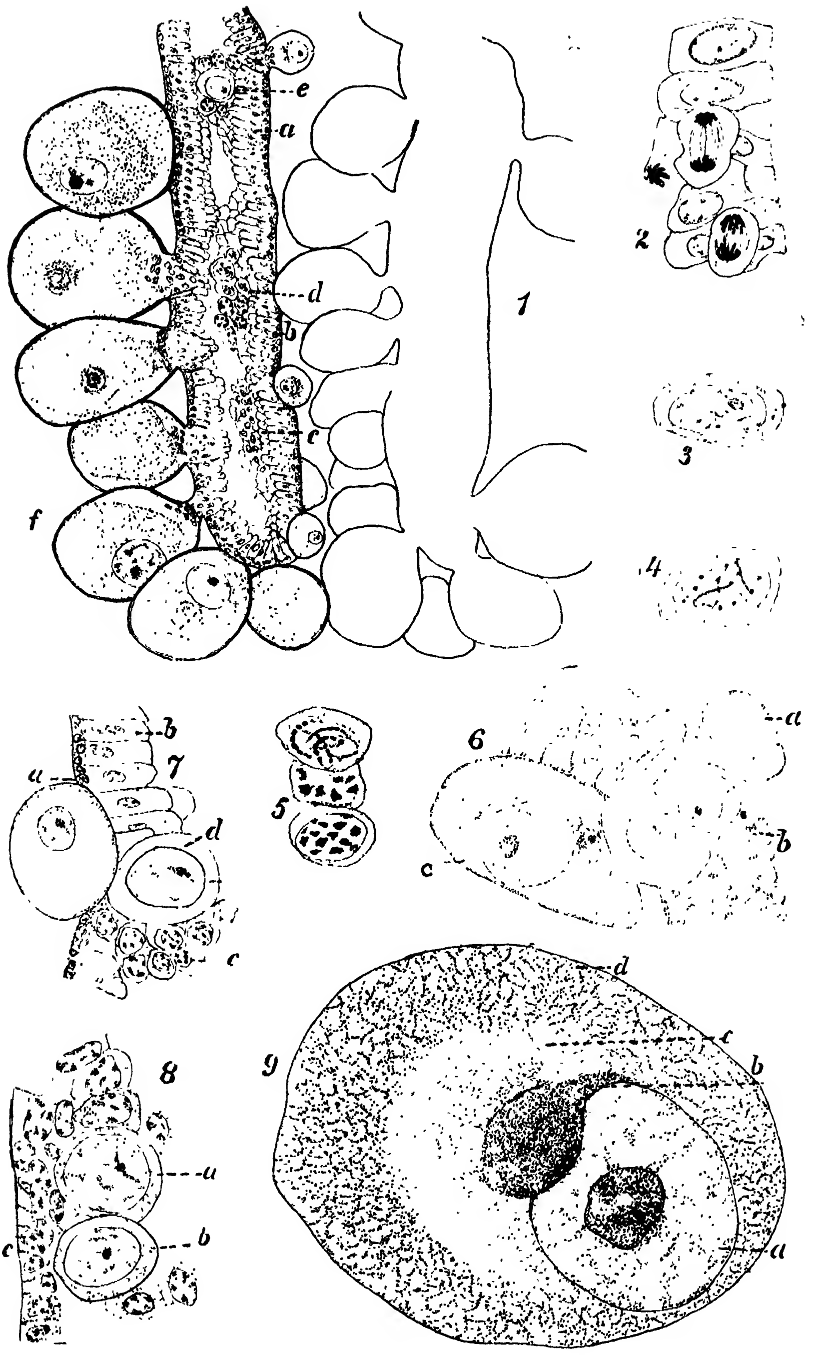


PLATE XIII.

FIG. 10.—Young follicular oöcyte in which the vitelline body, *a*, is developing. Here is seen in this stage scarcely more than the central vesicle, the whole clouded by a zone of darkly staining granules. The body is distinctly a part of this zone. *b* is the germinal vesicle and *c* the stem of epithelial cells which attaches the egg to the ovary.

FIG. 11.—An oöcyte somewhat older than at figure 10, in which the vitelline body is assuming a concentrically striated wall. The clear central part of the body is the central vesicle, though it possesses no well-defined wall, as in figure 10. Near the periphery is a vacuole, *a*.

FIG. 12.—The vitelline-body has moved out from the nuclear wall. It not only lies in the vitelline-zone, but is closely surrounded by a dense layer of granules. This is probably food material which it is extracting from the zone and is storing up. Between the periphery of the vitelline body and the central mass is a coarse network, which I take to be no more than the cytoplasmic reticulum made prominent by the deutoplasmic granules which adhere to it.

FIG. 13.—The vitelline body is now separated from the germinal vesicle by almost the diameter of the cell. It here possesses a clearly defined outer edge, which separates it sharply from the surrounding structures.

FIG. 14.—Instead of a body formed of concentric layers, there is a collection of large globules which stain very black in iron-hæmatoxylin. Those at the center are in the shape of rods, and resemble chromosomes.

FIG. 15.—A follicular egg, showing the egg-stalk, *a*, attaching the large oöcyte to the ovarian wall. The vitelline body possesses a wall spirally wound about the central vesicle.

FIG. 16.—The germinal vesicles of eggs at this stage of development possess very large nucleoli, which are usually vacuolated. The smaller bodies stain darker, and have much the appearance of being cast from the nucleolus.

FIG. 17.—A highly magnified vitelline body, showing its well-defined outer edge and the network of fibers within.

FIG. 18.—A follicular oöcyte, showing the peritoneal coat, *a*. Here are found again some new characteristics in the vitelline body. The central vesicle is comparatively large and distinct, and instead of being clear is filled with darkly staining rods, or pseudo-chromosomes.

FIG. 19.—There is shown here a condition which is very rare. The cytoplasm surrounding the vitelline body is faintly radially striated.

PLATE XIII.

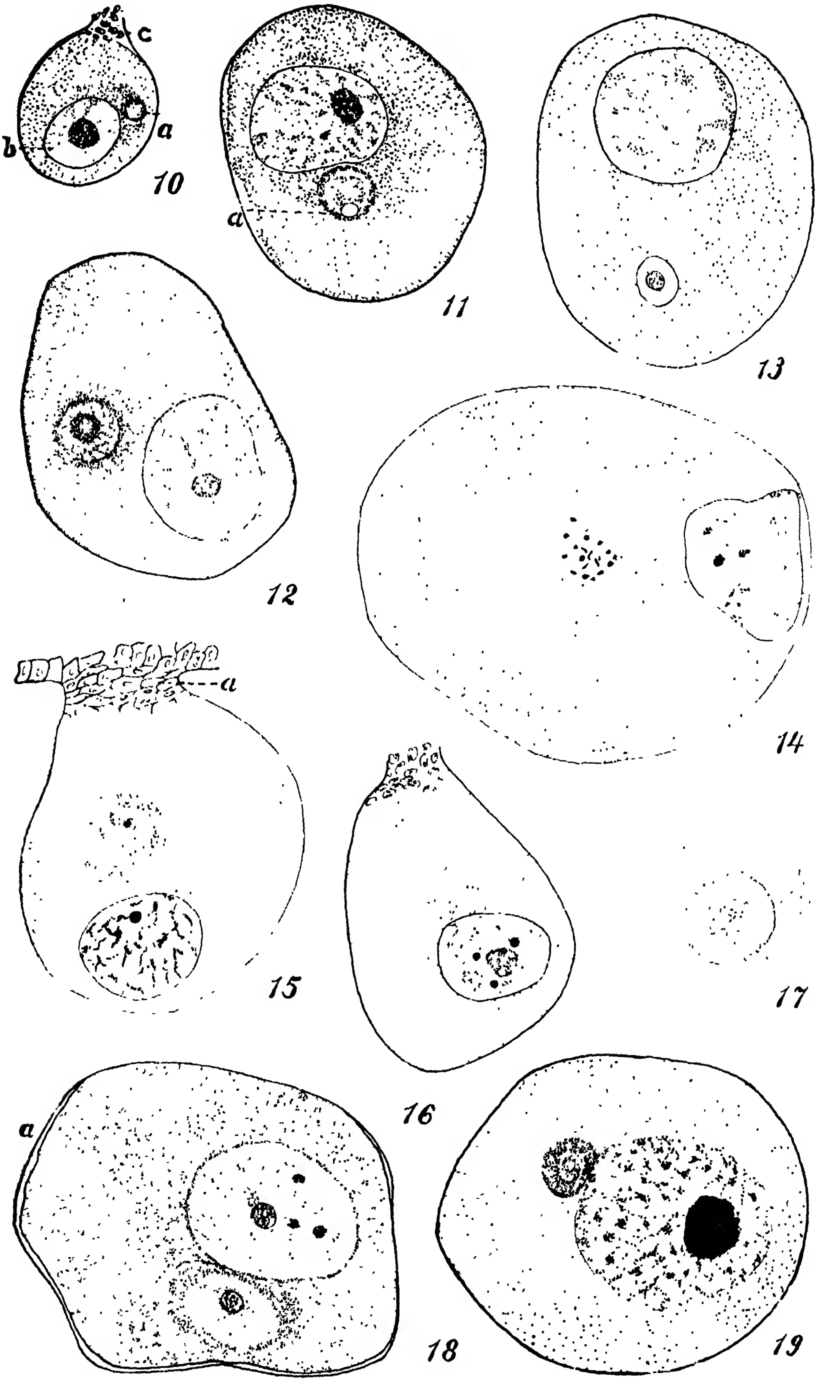


PLATE XIV.

Fig. 20.—The vitelline body shows a distinct central vesicle, and a striated capsule, the outermost layer touching the nuclear wall. The cytoplasm seems to be drawn toward the body from all directions. The nucleolus is very characteristic of the nucleus just now. The clear vesicle within is filled with very dense bodies, which do not take the stain, but shine with a metallic luster.

Fig. 21.—The cytoplasm throughout this egg is clear and uniformly reticular. At *a* is the vitelline body. At *b* and *c* are structures identical with the central vesicle of figure 18, plate XIII; *b* is especially clear, with a well-defined wall and equally well-defined pseudo-chromosomes within. This multiplication of the structure which we have called the central vesicle seems to show that it is not confined to the vitelline body, and, moreover, seems ample proof that it is not the centrosome of the spider egg.

Fig. 22.—The vitelline zone, *a*, is conspicuous in the early follicular eggs. It extends from the nurse-cells in the stalk almost to the periphery of the egg.

Fig. 23.—A peculiar appearance of the oöcyte, in which the yolk globules, *a*, have begun to form about midway between the periphery and the center.

Fig. 24.—An oöcyte almost ready to leave the follicle. The stalk, *a*, is very small and the nurse-cells few and reduced in size. A membrane, *b*, seems to be forming between the nurse-cells and the egg contents.

Fig. 25.—Two oöcytes just previous to forming the follicle. There is at this time no trace of a vitelline body.

Fig. 26.—An oöcyte in which the concentrically striated capsule of the vitelline body is very distinct. At the center may be seen a sphere much smaller than any yet found. There seems to be little uniformity in size of this formation, which fact throws doubt upon its being a definite structure.

Fig. 27.—Here again, as in figure 21, are two structures, besides the perfectly developed vitelline body, simulating the central vesicle.

PLATE XIV.

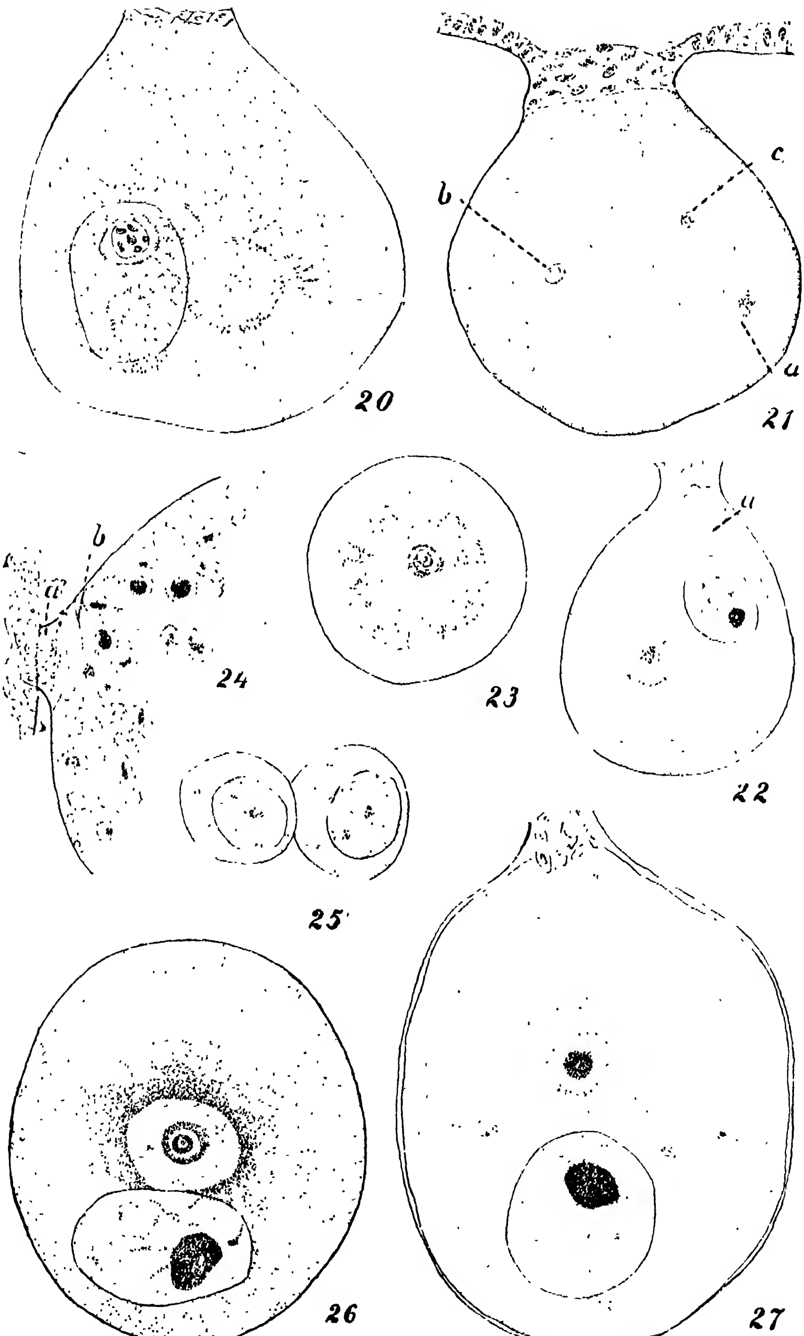


PLATE XV.

Fig. 28.—Yolk is beginning to form at the periphery of the egg. *a*, yolk globules; *b*, the yolk-nuclei of Foot; at *c* we meet with a peculiar condition of the vitelline body. The structure no longer retains its spherical form, but shows one side broken away and the contents scattered. The body has every appearance of disintegrating.

Fig. 29.—The vitelline body much vacuolated. There is merely a remnant of the concentric layers left, and the entire structure seems to be dissolving and mingling with the cytoplasm.

Fig. 30.—Another vitelline body which shows no central vesicle. The structure has a spongy appearance and no concentrically arranged border. *a* and *b*, yolk globules.

Fig. 31.—Oöcyte completely filled with yolk. The nucleus and vitelline body are once more close together, connected by the scanty cytoplasm which remains in the cell. *a*, yolk globules; *b*, nucleus; *c*, vitelline body.

Fig. 32.—Egg about ready to leave the follicle. The neck is rapidly diminishing and the egg membrance is forming at *c*. The entire egg is at this time filled with yolk, *a*, and the nucleus is close against the cell-wall, this being the position of nuclei just before maturation in centrolecithal eggs.

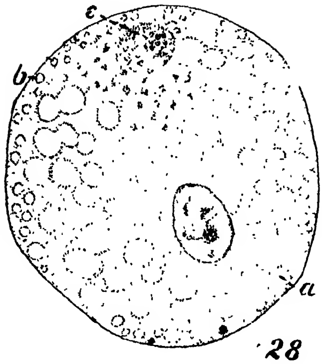
Fig. 33.—Portion of another egg preparing for maturation. There is no trace of the vitelline body applied to the nucleus, as was found a little earlier in figure 31. The assumption is that it has been left behind, though at this stage so much yolk obscures it.

Fig. 34.—The assumption concerning the vitelline body of figure 33 is proven true by this figure. Here is a segmenting egg. The nucleus at the periphery has divided, forming the cells, *a*. At the center, among the yolk globules, we find the vitelline body, *b*, unchanged.

Fig. 35.—A follicular egg of *Epeira*, which represents those eggs without the vitelline body formation. Numerous patches of food material cloud the cytoplasm.

Fig. 36.—Highly magnified vitelline body, showing the central vesicle, *a*, and the rod-like structures within.

PLATE XV.



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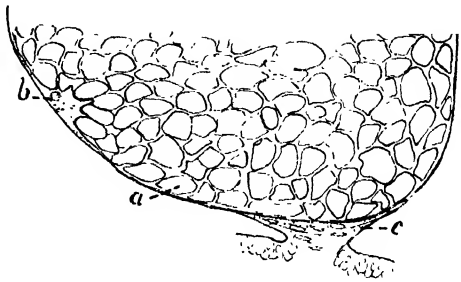

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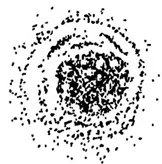

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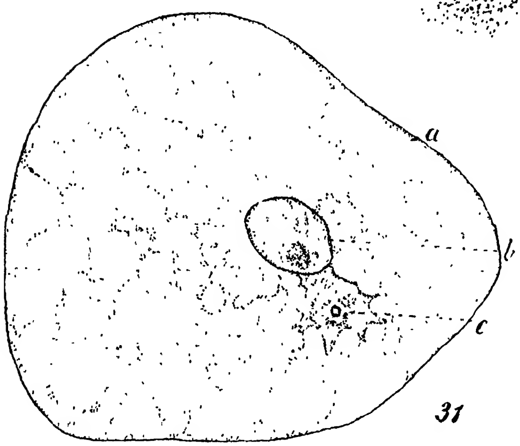

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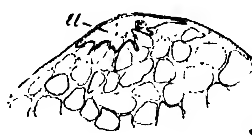

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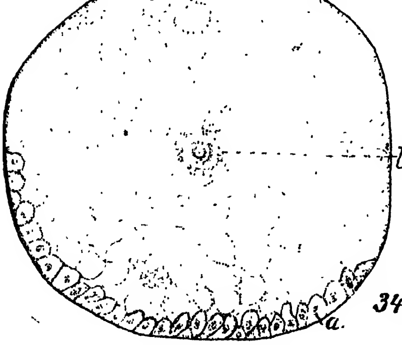

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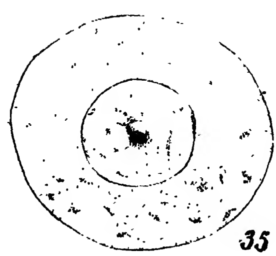

35

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CONTENTS

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THE FUNCTIONS OF THE NERVOUS SYSTEM, WITH SPECIAL REGARD TO RESPIRATION, IN ACRIDIDÆ.

BY HENRY Z. EWING.

From the physiological laboratory of the University of Kansas.

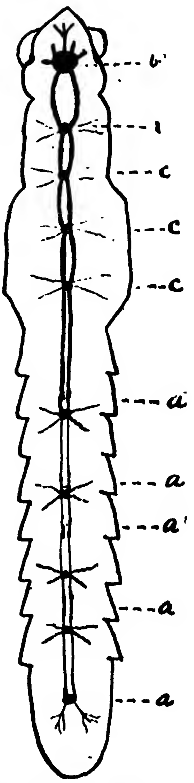
IN my experiments I have not confined myself to any one species of the Acrididæ, but have used any of the common ones that could be easily obtained, especially different species of the grasshoppers, *Melanoplus differentialis*, *Dissosteira carolina*, *Melanoplus femur rubrum*, and *Brachystola magna*, the latter being an especially good species for experimentation, because of its size. I have not noticed in results of experimentation in the different species any differences that might not have been observed in individuals of the same species.

Of the literature bearing upon this subject, Bethe's work[1] is perhaps the most important. I was able to corroborate many of his observations on the grasshopper, and with abundant material, while he had but few animals to experiment on.

My work is not all new, yet I think those facts which I have been able to add to those previously determined, justify me in offering this paper for the consideration of those interested in insect physiology.

Before proceeding with my subject proper, I shall briefly describe the respiratory and nervous systems of the grasshopper, in order to make my paper intelligible to those unacquainted with the anatomy of this insect. The three principal parts of the respiratory apparatus are the spiracles, air-sacs, and tracheal tubes. There are twelve spiracles on each side, three thoracic and nine abdominal. By means of these and the trachea an interchange of air takes place. One very large pair of air-sacs is situated in the thorax and five abdominal pairs arise

1. Bethe, W. Pflugers, Archiv fur die Gesammte Physiologie, 1897, vol. 68, p. 494.



NERVOUS SYSTEM OF THE GRASSHOPPER.
Diagramatic.
a. Abdominal Ganglia.
d. Infra-œsophageal Ganglion.
b. Supra-œsophageal Ganglion or Brain.
c. Thoracic Ganglia.

directly from the spiracles. In addition to these superficial air-sacs there are very many, probably several hundred, distributed throughout all parts of the body. Of the tracheal tubes there are two main trunks on each side. One is placed above and the other below the plane of the alimentary canal. They communicate with each other and with the air-sacs and spiracles. Besides these large trunks there are countless ramifications to all parts of the body, communicating by their finest twigs with internal cells. The oxygen of the air is thus separated from the fluids of the body by a very delicate endothelial membrane.

The respiratory movements in the normal grasshopper consist of an expiratory and an inspiratory phase. During inspiration the active contraction of the abdominal muscles produces an increase in the breathing space, in that the antero-posterior and dorso-ventral diameters of the abdomen are increased, and air passes in through the open spiracles to fill the air-sacs, since the pressure within, in consequence of the formation of a partial vacuum, becomes less than atmospheric. In active or forced inspiration, the abdomen may be elongated, and by a forward and backward movement of the head, the air-spaces in the abdomen may be still further increased. Expiration is a passive movement; that is, the muscles relax and the breathing space is decreased as the abodmen relaxes by its own elasticity. At the same time the return of the abdominal segments to closer contact with each other, forces the contents of the air-sacs along the tracheal tubes into their finer ramifications, and also expels air that has been in contact with the fluids of the body into the air-sacs and thus to the exterior of the body.

The nervous system of the grasshopper consists of a supra-

œsophageal ganglion or brain proper, and a double chain of ganglia on the ventral side of the body, composed of one sub-œsophageal, three thoracic and five or six abdominal ganglia connected by a double nerve fibre with each other and with the brain. Each ganglion consists of two halves intimately united by a transverse commissure.

The experiments, in the course of which the following notes were made, consisted in removing or severing, by means of fine, sharp, curved or straight scalpels or scissors and hooked forceps, different parts of the nervous system of the insect. The nervous system had been carefully studied and outlined in relation to definite landmarks on the exterior of the body. During the operation the animal was held in an insect holder, while the parts of the nervous system were exposed and removed with aseptic precautions. The regions from which parts were removed were examined under the microscope, to ascertain whether more or less of the planned lesion had been executed. The chitinous piece was replaced then over the wound and held in place by shellac or wax cement. The insects were kept under fairly constant external conditions throughout the period of observation. A post-mortem was made in most cases.

My work was pursued under the supervision of Professor Hyde, of the physiological department, to whom I am indebted for much valuable assistance.

I. Extirpation of the Brain.

The rate of the respiratory movements was slowed, otherwise this operation has no marked effect upon respiration. Pinching the antennæ, which, after the brain is removed, remain motionless in any position in which they are placed, produced no reflex movements. There are evidently no sensations left in these organs, although the grasshopper would still stroke them with his front feet, as the normal animal occasionally does to clean them. Bethe observed this action and thinks that in the operation a stimulus is aroused in the inferior œsophageal ganglion that is similar to a stimulus produced by the antennæ in the intact animal. The head is lowered sideways, the fore leg is stretched toward the region where the antenna is normally found. Contact with the antenna causes the foot reflexly to take an increased hold on it and to press it to the ground, as if to prevent the escape of the seemingly foreign body. The

pull thus executed reflexly causes the head to be raised. When I cut off one antenna from a normal hopper the head was bent, the fore leg extended to where the antenna normally was and the wound rubbed. When the other antenna was removed the insect rubbed first one then the other side of the head where the wound was, going through the different phases of the reflex acts noticed in the case above, first with the front leg of the one side and then with that of the other side. This, in part, proves that Bethe's interpretation of the behavior was correct, and that as the result of the operation a stimulus was created that caused the front legs to remove the irritant.

Faivre[2] considered the supra-œsophageal ganglion of the beetle, the seat of spontaneous movements, direction, and will; and Ward[3] that in the crayfish it was comparable to the cerebellum of vertebrates, since its loss is followed by the disappearance of spontaneous activity. Lemoine,[4] Treviranus[5] and Burmeister[6] regard the supra-œsophageal ganglion of arthropods the seat for spontaneous movements; and Leidig believes that the supra- and sub-œsophageal ganglia together are analogous to the brain of vertebrates. On the other hand, Yersin[7] observed that a cricket occasionally moves spontaneously after its brain or supra-œsophageal ganglion has been destroyed. Bethe affirms that the brain, besides being the seat of peripheral nerves, the centre for inhibitory reflex movements, and for controlling the tonus of the muscles, (each half of the brain exerting its influence over its own side,) is not the special centre for spontaneous movements, inasmuch as spontaneous movements were not lost in those arthropods that had their supra-œsophageal ganglion extirpated. The spontaneous activity after the loss of the brain was, however, least observed in the grasshopper.

Added to this, Faivre, Ward and Bethe noticed that when the brains of the arthropods that they investigated were extirpated or separated from the other parts of the nervous system, the animals lifted their bodies above the normal level by increased contraction of the flexor muscles, whereby the legs were flexed

2. Faivre.—Comptes rendus, 1860, T. 51.
3. Ward, J.—Journal of Physiology, 1879, vol. 2, p. 214.
4. Lemoine.—Ann. d. scienc. natur., 1868, T. 9, p. 100.
5. Treviranus.—Die Erscheinungen des Organischen Lebens, Bremen, 1832.
6. Burmeister.—Handbuch der Entomologie, Berlin, 1832.
7. Yersin.—Bulletin de la Soc. Vaudoise d. sciens. natur. 1856, T. 5, p. 284.

at the joints and the body raised. Bethe observed this abnormal flexed condition of the appendages to pass off in the grasshopper after twenty-four hours, when the normal position of the body was practically assumed again.

I found that brainless grasshoppers continue to move their palps and occasionally wipe or preen the palps with their front legs for apparently no cause. Shortly after the operation they make a few spontaneous walking movements, that gradually become weak and wavering, so that during twenty-four hours it may be that they have only turned round, or taken one or two steps. During this time, however, they execute peculiar swaying movements, whereby the legs of first one side, then the other, are slightly raised from the ground. Similar movements are frequently observed however in the normal hopper.

The normal grasshopper stands with its body quite close to the table, the femur of the hind legs obliquely bent upwards, while the brainless animal assumes the position described by Bethe. By close inspection it is seen that, shortly after the loss of the brain, the two pairs of walking legs are flexed at the joints, so that they assume a straighter position, and point toward the median plane of the body instead of away from it. Thereby the thorax is elevated, while the jumping-legs are no longer held obliquely with the abdomen but more parallel to it. In addition to this, it is observed, that the head is lowered so that the palps touch the table. During the following hours, however, the flexed condition of the legs gradually disappears, and they assume finally an abducted posture, so that the abdomen rests on the table and the walking legs are more extended from each other.

Usually, when a normal hopper is taken in the hand, the respiratory movements cease for a few seconds, being inhibited through the stimulus of touch or temperature of the fingers. This inhibition is not observed in the brainless hopper, under this circumstance. I found, moreover, that for about one hour after the brain is destroyed, the slightest touch will often cause the animal to fly or hop, a much stronger touch being normally required to excite this response. It may either jump once for each stimulus, or take one or two steps and then stop. If its wings are held with forceps it makes a weak attempt to walk away, but it does not jump or endeavor to remove the annoying

stimulus. Upon freeing the wings it takes a step or two, then stops. Though the legs follow their normal order in walking, they may first be lifted and flexed in a peculiar way before they are placed on the ground. It is further shown, that coördination is not destroyed, in that the hopper alights in quite a normal manner after a hop, and when placed on its back turns over in a perfectly coördinated manner, though seemingly exhausted from the effort. It must be added that it, as well as the normal hopper and crayfish, will remain on its back, as if hypnotized, if placed there with greatest care and careful handling.

If the palps are touched with a blade of grass, the mandibles and maxillæ begin to move, but no grass is bitten off, and sugar-water or soaked raisins, which normally are never refused, are no longer tasted or swallowed. Pinching the palps slightly causes them to move, and if acid is put on the palps it is at once rubbed off by the front legs. If the hopper is placed on a blade of grass held vertically, it will attempt to climb upon it by taking one or two steps upwards, and will cling there, but only for a short time, as it soon becomes exhausted from the effort. If one foot is pressed it takes a step in the direction of the non-stimulated side. Bethe observed that after the brain was removed these animals fluttered their wings rhythmically, but never rose higher than the level from which they started; but I have seen them fly much higher shortly after the brain was destroyed.

When all but a narrow strip of nerve tissue from which the optic nerves arise is removed from the brain tissue, the insect hops, flies and walks incessantly for hours, keeping its head close to the table, its abdomen high above it, and when it alights from hopping, it seems to have lost all sense of equilibrium, or is completely exhausted. In this case the sight may have been destroyed, and this fact may interfere with its equilibrium, while inhibition of motion may be due to a constant stimulus produced by the operation. Muscular weakness or loss of tone may explain the abnormal position of the head retained by the animal. Grasshoppers operated on in this way, behave more like those arthropods that Bethe investigated, since extirpation of their entire brain caused spontaneous and prolonged activity. The above observations show that in the

brainless grasshopper spontaneity persists only to a slight extent. The preening and palp movements, the occasional lifting of the legs of first one side then the other, and the progressive movements of a step or two during twenty-four hours, are activities produced without any apparent external cause and may be regarded as spontaneous.

Moreover, Bethe has demonstrated that in brainless arthropods the power to inhibit reflex movements is lost. They respond to stimuli too slight to elicit reflexes in normal animals, and keep up constant preening and masticating movements and varied activities of the legs; while some, as for instance the water-beetle, not only retains its progressive locomotor movements, but walks incessantly. I observed that the brainless hopper has also lost the power to inhibit reflex movements. It also exhibits the palp and preening movements, as well as the restless lifting of the legs, and responds to the slightest touch by hopping, but it does not make progressive locomotor movements of more than one or two steps during twenty-four hours, and its respiratory movements are no longer inhibited when it is first taken in the hand.

The change in flexion of the legs, followed by the weakened condition of the body, manifested by resting its head against the table, and the quick exhaustion after any effort, indicates, as will be pointed out later, that the brain exercises a control over tension of the voluntary muscles.

Coördination, however, as well as direction, still persists with the loss of the brain, since the hoppers in walking move their legs in normal order, turn over if placed on their backs, can hop, fly and alight in a normal manner, and move toward the unstimulated side when a leg is pressed.

II. Removal of Half of the Brain.

Extirpating half of the brain, by every operative precaution above spoken of, produced no material change in the respiratory movements, and the spiracles of both sides moved in the normal member. If the right half, for instance, is destroyed, sensation persists in the left, not in the right antenna, and the abdomen is curved toward the left side. The right walking-legs are flexed, so that the animal stands higher on the operated side, while the right jumping-leg is extended and, in walking, seems to propel the right side of the body onward. The wing

on the injured side is folded; that on the uninjured is partly spread. The animal may have been sluggish before the operation, but immediately afterward it is very active, moving in a circle toward the uninjured side. If it is placed on a table, with its left side very close to the edge, and stimulated, especially by touching the palps on the operated side, which are now more sensitive and produce more marked reflex responses than those on the unoperated side, it will at once fall from the table. The direction in which the animal hops may be either toward the left or the right, but shortly after the operation it hops usually toward the unoperated side. When placed on its back it turns over, but not so readily as does the normal animal.

About five hours after the loss of half of the brain, it is noticed that the hopper stands more erect; that is, inclines less strongly toward the unoperated side, and, by close inspection, it is seen that the legs on the operated side are not flexed so much as they were. Pressing either palps, wings, legs or the irritable antenna now causes the animal to move in a nearly straight line. Yersin and Bethe observed that insects that had half of the brain destroyed would gradually lose the inclined posture and respond finally to a strong stimulus by going either to the right, left or straight forward, depending upon the region stimulated. Bethe believes that the appendages on the operated side are weaker, and their reflexes are less inhibited than those on the unoperated side. His explanation is that the brain exercises a tonus over the muscles and an inhibition over reflex movements. When half of the brain is removed, therefore, the muscles on the operated side lose their tonus, become weaker, and the reflex responses are no longer inhibited, as they are in the normal animal. This view would explain some of the results of lesion to half the brain, but it does not entirely explain why the flexed position on the injured side gradually disappears. It seems that the flexors of the injured side and the extensors of the uninjured side, are stimulated; or that the extensors of the operated side and flexors of the unoperated side are inhibited, or have lost their tonus. Moreover, it seems that the same region of the brain controls these muscles which normally act together for a definite movement, and are associated and situated on opposite sides of the body, as, for instance, the flexors of one side and extensors of the other. As a conse-

quence of the unsymmetrical posture of the appendages, the animal moves in a circle.

III. Extirpation of the Subœsophageal Ganglion.

Removal of the subœsophageal ganglion is attended with much difficulty, but with great care it was removed without loss of much blood. The wound was closed with shellac. The loss of this ganglion does not stop the respiratory movements. The respiratory centre is therefore not located in this part of the nervous system, which is therefore not analogous to the medulla in vertebrates, as Faivre and others maintained. The spiracles of the abdomen and thorax continue their activity at a slower rate, and, as in the normal animal, the abdominal and thoracic spiracles often do not keep the same rhythm. Moreover, some of the spiracles on one side of the thorax may be motionless, while those on the opposite side are active. This is explained by the fact that each half of the ganglion innervates its own side of the body. The relation, however, between the two halves is so intimate that they usually act together in producing ordinary movements. The palps remained motionless; when they were strongly pinched they did not respond.

Shortly after the operation the head droops and touches the table, and the antennæ may remain in the position in which they are placed, *e. g.*, one pointing anteriorly and the other posteriorly. It hops but does not walk unless it is irritated. It remains for about an hour in any position in which it is placed, after which the shock effect passes off. If any part of the thorax or abdomen is pinched, reflex movements of the different parts posterior to the injury are observed, but no reflexes of parts anterior to the cut follow. It moves spontaneously after two hours, dragging its body along as if it were a heavy load. Its first pairs of walking-legs are abnormally flexed, and therefore do not coördinate in a normal manner with the others. This is because their nerve fibers were injured or stimulated by the operation. If it meets an obstacle it may fall over on its side, but immediately, though awkwardly, rights itself. In all the movements there seem to be a lack of perfect coördination for at least twenty-four hours.

Faivre believes, from his experiments on *Dytiscus*, and Ward from those on the crayfish, that the subœsophageal ganglion is

the seat for coördinate movements. Bethe, however, does not regard the subœsophageal ganglion as the centre for coördinate action, since most of the arthropods that he operated on showed few or no disturbances in coördinate movements after its removal. In the grasshopper, as we have seen, the subœsophageal ganglion is not the chief centre for coördinate movements. The destruction of the ganglion is followed by a severe shock effect because it is accompanied by a great loss of blood and necessitates a wound in a sensitive area. The insect can still hop, fly, walk, and right itself, but in an awkward manner, and shortly after the operation it seems to have lost its sense of equilibrium. From the fact, however, that decapitation of the grasshopper does not, as shall shortly be pointed out, destroy coördinate progressive activities, it is evident that the ganglion in the grasshopper does not preside over coördination of these movements, though it may exert some influence over the sense of the position of the body in space.

IV. Decapitation.

The supra and subœsophageal ganglia are removed by cutting off the head. Usually a ligature is tied around the neck before the head is cut off to prevent loss of blood. As was to be expected from the foregoing experiments, the respiration was not materially altered by the operation. It was only decreased in rate. The lack of coordination in the rate of the thoracic and abdominal spiracle movements, however, which may be observed, is not due to any operative disturbance, since, as was said before, this irregularity exists in normal insects.

If a narrow strip of chiten is removed from the side of the abdomen in a decapitated hopper, it is seen that the air-sacs inflate in the inspiratory phase, and that, when the animal struggles, the spiracle movements increase in frequency with the movements of the abdomen and inflation of the air-sacs.

Twenty-four hours after being decapitated, the animal hops and flies four or more feet if it is touched. This depends upon the species; some normally fly further than others.

When it is placed on its back it struggles and turns over, but not so promptly as does the normal one. If, however, it is carefully placed either on its side or back, it will remain so, and, if its feet hold on to a stick, it will not attempt to right itself from any position in which it is placed by changing the

position of the stick. In standing, it may incline more to one side, and often remains in any position in which it has been placed; as, for instance, the thorax touching the table and the abdomen and jumping-legs raised far above it.

It makes purposive reflex movements, though these are not as strong as in the normal hopper, and the power of localization is still left. If any part of the body easily reached by the feet is touched, they attempt to push away the offending object, for instance, if the posterior part of the abdomen is touched with a pencil, first one then the other leg tries to push away the pencil. If the insect is held with the fingers, it struggles to free itself, and, as in the case in the normal hopper, both the abdominal and thoracic spiracles and the abdominal respiratory movements are increased in rate and force. During the first hours it moves, hops and flies spontaneously; that is, without any apparent cause. These movements may be due to operative disturbances. The egg depositors open and close rhythmically and fœces are often excreted, and it often sways from side to side while standing.

The results obtained from this experiment corroborate, in many respects, those already cited. This method of removing the subœsophageal ganglion is very simple and satisfactory, from the fact that all of the ganglion is removed.

V. Removal of Thoracic Ganglia.

The thoracic ganglia are easily exposed on the ventral side. The first is covered by a chitinous plate lying between the first pair of legs. It is successfully destroyed with a hot needle, or can be cut out with a very fine hooked scapel or bent scissors, and the wound covered with shellac. After the shock effect produced by the operation has passed off, the respiratory movements of the abdomen and spiracles continue at about half of the rate observed before the operation. There is, however, complete loss of motion of the first thoracic spiracles, as well as loss of motion and sensation in the first pair of legs. It flies, hops and walks with its second and third pairs of legs, and with the aid of these turns over when placed on its back. Evidently the centre for the turnover reflex is not located in the prothoracic ganglion, as Faivre believed it to be in the water-beetle. When the antennæ are pinched there are no responses in the walking-appendages, and pinching either the second or

third leg produces responses only from these, and fluttering of the wings and wing-covers.

When the second thoracic ganglion is removed, there is a decrease in the rate of respiratory movements, loss of motion in the second thoracic spiracle and of sensation and motion in the second pair of legs, and loss of the power of flight. The animal hops and walks, but does not move the second pair of legs. It tries to turn over if placed on its back, but cannot without its front and jumping-legs. If the antennæ are pinched it uses its front leg to push away the forceps; if the hind legs are pinched it does not push away the forceps, but hops away. Faivre found that the respiratory movements in the water-beetle ceased upon removal of the meso-thoracic ganglion, and only reappeared upon stimulation, and then only when the meta-thoracic ganglion was still intact. My results do not agree with this, since I found that respiratory movements continue without stimulation after extirpation of this ganglion, and the respiratory movements of the abdomen are not greatly changed by the simultaneous removal of this and the meta-thoractic ganglion.

After extirpation of the third thoracic ganglion, only the rate of respiration is affected. Motion and sensation in the third pair of legs are lost, as is also the power of flight. The third thoracic spiracle is inactive. The insect turns over when placed on its back. When the abdomen is pinched the legs remain inactive. It can still make progressive movements with its two pairs of walking-legs.

The air sacs in the thoracic region, even after removal of all the thoracic ganglia, continue to expand and contract with the movements of the abdomen and independently of the thoracic spiracle movements.

VI. Removal of Abdominal Ganglia.

The abdominal ganglia are extirpated from the ventral side of the body by removing a small piece of chitin that lies directly over the ganglia. They were destroyed with a hot needle or extirpated with bent scissors or hooked scalpel. The wound was covered with shellac.

When the first abdominal ganglion is destroyed there is a loss of motion in the first abdominal segment and its spiracles, but all remaining parts of the body continue actively in the

normal manner after about half an hour following the operation, or until all shock effects have worn off. By the removal of the successive abdominal ganglia of the ventral chain like results were obtained, but in addition to these there is a loss of motion in the ovipositor when the last abdominal ganglion was removed.

By severing the longitudinal commissures between different ganglia of the abdominal ventral nerve-cord, or by severing the abdomen from the thorax and cutting it transversely into two or more parts, it is found that the different parts into which the abdomen is divided continue to execute rhythmical respiratory movements, provided the removed piece contains at least three segments. This is in accord with the results obtained by Miss Hyde[8] in *Limulus*.

The respiratory and spiracle movements in the abdomen may stop for a shorter or longer period of time after the abdomen is cut from the thorax, and then spontaneously begin their movements again, or they may continue uninterruptedly but with less frequency and with less force. Moreover, if two drops of a half per cent. curare are injected into the abdomen of a large grasshopper, all voluntary muscles and respiratory movements and spiracles seem paralyzed for from two to six hours. The spiracles are closed, and the abdomen is relaxed in the expiratory phase. This proves that inspiration is due to an active contraction of certain voluntary abdominal muscles.

If a transverse section is made between the third and fourth abdominal segments a small pulsating organ is seen. It is situated close to the ventral side of the body below the alimentary canal and almost directly opposite the heart. I have been unable to determine from literature what it is.

VII. Conclusion.

1. Neither the supracœsophageal ganglia or brain of the grasshopper nor the subœsophageal ganglion, which has been regarded by some authors as analogous to the medulla of vertebrates, is the centre for respiratory movements. Furthermore, the meso-thoracic and meta-thoracic ganglia, which, according to Faivre, presides over the respiration in the water-beetle, *Dytiscus*, do not control the mechanism of the respiratory move-

8. Hyde, I. H., Journal of Morphology, 1897, vol. 9, No. 3, p. 431.

ments in the grasshopper. Each ganglion of the thoracic and abdominal ventral cord is the centre for respiratory movements, and reflex actions of the segment and the appendages to which it belongs. Not only the whole abdomen, but different segments of it will continue their respiratory activity when severed from the body.

2. The posterior part of the brain exerts an inhibitory power over the anterior part of the grasshopper's brain. The anterior part of the brain is the seat for spontaneous progressive locomotion. If the posterior part of the brain is destroyed, leaving the anterior strip of the brain tissue in tact, the animal moves incessantly. If, however, the whole brain is destroyed, the grasshopper stops its progressive movements almost entirely; it takes only a step or two in twenty-four hours.

3. The brain of the grasshopper is the centre for swallowing movements and for inhibiting reflex movements. With the loss of the brain, the animal neither moves its mandibles nor swallows food, and it now responds to subnormal stimuli in an exaggerated way by hopping or flying. Moreover, the palp and preening movements, as well as the rhythmical lifting of the legs are of frequent occurrence, and for no apparent cause.

4. The grasshopper's brain is not the centre for cöordinate movements and direction. Since, when its brain is removed, the insect will respond when stimulated by walking, flying, hopping and righting itself in a normal manner, and will, moreover, move in a direction away from the irritating cause.

5. The brain controls the tonus of the muscles, since after its extirpation, although the grasshopper makes purposive movements to defend itself, it does not do so nearly so powerfully as does the normal animal, and it is very soon fatigued. The position of the head and appendages is altered when the brain is destroyed. The head droops, the flexor muscles of the legs contract, so that the appendages are at first strongly flexed and then extended beyond the normal, due possibly to the contraction of the extensors or inhibition of the flexors. The influence exerted by the brain over the tension of the voluntary muscles is also illustrated by the position of the legs and body, as well as by the direction of progressive movements, when half of the brain is extirpated. During a definite period of time the hopper then inclines more to the side, and moves in a circle toward the un-

injured side, indicating that the flexors of one side and the extensors of the other are affected, and that each half of the brain, though controlling the reflexes of its own side, also exerts to a certain degree a power over the associated muscles of the opposite side.

6. The subœsophageal ganglion is not the center for correlated movements in the grasshopper, as Ward found it to be in the crayfish. Since the turn-over, reflex, walking, hopping, flying and alighting persist not only when it is removed, but when the whole head is cut off. The subœsophageal ganglion exerts, however, to a certain degree, an influence over the sense of equilibrium. The preservation of the segmental arrangement of the nervous system enables the animals to execute the progressive movements.

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CONTENTS:

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LISTS OF COLEOPTERA, LEPIDOPTERA, DIPTERA AND HEMIPTERA

COLLECTED IN ARIZONA BY THE ENTOMOLOGICAL EXPEDITIONS OF THE UNIVERSITY OF KANSAS IN 1902 AND 1903.

BY F. H. SNOW.

A combination of two papers, read at the thirty-fifth and thirty-sixth annual meetings of the Kansas Academy of Science, January 2, 1903, and November 27, 1903.

THE above-named expeditions made insect collections in four localities. First, near Thomas's ranch, in Oak Creek Canyon, about twenty miles south of Flagstaff, in Coconino county, at an altitude of 6000 feet, August 13 to 25, 1902; second, at "Windmill Spring," near Dilman's ranch, on the north side of Humphrey's peak, one of the San Francisco mountains, about fifteen miles north of Fagstaff, altitude 9500 feet, August 26 to September 4, 1902; third, Martinez, or Congress Junction, in Yavapai county, 125 miles south of Ash Fork, altitude 3000 feet, July 22 to August 1, 1903; fourth, near Tappan's ranch, on the Bill Williams' Fork of the Colorado river, which separates Mojave and Yuma counties, altitude 1000 feet, August 3 to September 3, 1903. The camps of 1902 were located in a typical mountain environment; those of 1903 were in the arid, sandy and hot desert region of southwest Arizona.

Oak Creek Canyon has precipitous walls from 1200 to 1500 feet high, and is a miniature edition of the Grand Canyon of the Colorado, but with an abundance of stately oaks and pines and beautiful wild flowers, and luxuriant farm crops on the two or three ranches on the narrow floor of the canon. Oak creek is a vigorous mountain stream of clear, cool water, and is well stocked with luscious trout. No wagons can enter this canon, and our baggage, camp equipment and provisions were packed on

horseback down a zigzag trail, the members of the party carrying by hand all articles of a fragile character. A more delightful collecting region could not have been selected.

"From the second camp, at the base of the highest mountain peak of Arizona, two trips were made to the summit, but with results of an unexpected character. It is a well-known fact that the insect fauna above timber-line in Colorado is of a very different character from that of the region below timber-line. The writer had previously collected insects on Pike's peak, Gray's peak, and Long's peak. Here we found the *Parnassius* butterflies, the White-mountain butterfly (*Chionobas semidea*), *Colias meadii*, *Syngrapha hochenwarthi* and other species not found at the bases of these mountains. But at the summit of Humphrey's peak, in Arizona, 12,800 feet above sea level, no insects were found which did not also occur at the lower altitudes. *Vanessa californica* and *Pieris occidentalis* were common, both at the base and summit, while the common lady-bird *Hippodamia lecontei*, and the false chinch-bug *Nysius californicus*, were exceedingly abundant, both the latter species occurring over the entire region of the plains and mountains west of the Missouri river. The most probable explanation of this notable difference in the high-altitude fauna of Colorado and Arizona appears to be that the glacial ice mass did not extend so far south as the San Francisco mountains, and thus prevented the northern species from a more southern extension."*

At the third camp, where we left the Ash Fork and Phœnix railroad, about three miles from the famous Congress mine, the insect fauna was conspicuously different from that of the mountain camps of 1902. Almost every species was new to our experience as collectors. We were impressed with the profusion of insect life in an environment apparently so unfavorable. At the little town of Martinez every drop of water used by the inhabitants for all purposes is brought by rail from Date creek, sixteen miles to the north. The maximum temperature each day did not fall below 104 degrees (F.) and on one day rose to 116 degrees.

On the 1st day of August, 1903, we proceeded by wagon along

* This paragraph within quotation marks was read before "Section F," at the fifty-third annual meeting of the American Association for the Advancement of Science, at St. Louis, December 29, 1903.

the dry bed of Date creek and across the Cactus Plain to our fourth camp, which was located fifty miles west of Martinez and about three miles from Tappan's ranch, ten miles south of Artillery peak, on the left bank of the Bill Williams Fork, at a distance of about twenty-five or thirty miles from the junction of that stream with the Colorado river. Our tents were pitched near a lone cottonwood tree on the bank of the stream about half a mile from its entrance into the so-called "box canyon." There were two or three Mexican ranches within a mile of the camp, where we obtained an abundant supply of the most delicious muskmelons, and where the luxuriant alfalfa fields attracted a profusion of insects of all orders. At night we "sugared" for moths on the trunk of our cottonwood tree, securing large numbers of individuals, but a small number of species, of Noctuids. The three or four species of Mesquite furnished a considerable variety of coleopterous species, especially of the family Buprestidæ. The so-called "poly verde" was notably rich in desirable species.

My associates in the Arizona expedition of 1902 were Dr. Chas. F. Adams, Roy L. Moodie, and my son Frank L. Snow; in 1903 they were Doctor Adams, Geo. C. Mackenzie, and Eugene Smyth, and the success of the expeditions was largely due to the energy with which these fellow students devoted their attention to the work in hand.

I. LIST OF COLEOPTERA.

For the identification of species not readily determinable from the University collection, the writer is under obligations to Mr. Charles Liebeck and Mr. H. C. Fall.

Henshaw's numbers are used. Abbreviations for localities: O. for Oak Creek canon; H. for Humphrey's Peak at base; M. for Martinez (Congress Junction), and B. for Bill Williams Fork.

Family CICINDELIDÆ.

12. Tetracha carolina Linn. B.
20. Cicindela nigrocærulea Lec., var. M.
40. punctulata Fab. O.
57. lemniscata Lec. O. M.

Family CARABIDÆ.

73. Omophron obliteratum Horn. O. B.
...... Cychrus van dykei Roetschke. O.
...... n. sp. H.

119. Carabus tædatus Fab. O. H.
140. Calosoma simplex Lec. O. B.
221. Dyschirius tridentatus Lec. B.
273. Clivina ferrea Lec. M.
283. Schizogenius lineolatus Say. B.
286. amphibius Hald. B.
...... n. sp. B.
309. Bembidium carinatum. B.
330. complanulum Mann. B.
343. transversale Dej. M. B.
345. lugubre Lec. O.
351. lucidum Lec. H.
367. nubiculosum Chd. B.
391. versicolor Lec. B.
408. dubitans Lec. O.
436. Tachys vorax Lec. B.
449. nanus Gyll. O. H.
467. audax Lec. B.
468. rapax Lec. M.
525. Pterostichus constrictus Say. O.
579. lustrans Lec. O.
647. Amara latior Kirby. H.
670. interstitialis Dej. O. H.
670. interstitialis Dej. green var. H.
751. Calathus dubius Lec. O. H.
756. Platynus dissectus Lec. H.
771. brunneomarginatus Mann. var. O.
831. ruficornis Lec. ? O.
842. Lachnophorus elegantulus Mann. B.
864. Ega lætula Lec. B.
882. Lebia viridis Say. H.
941. Cymindis planipennis Lec. H.
...... Brachynus sp. O. H. B.
1008. Chlænius leucoscelis Chev. H. B.
1010. obsoletus Lec. B.
1034. Anomoglossus emarginatus Say. O.
1047. Oodes elegans Lec. B.
1080. Harpalus retractus Lec. O.
1081. amputatus Say. O. H.
1087. pennsylvanicus De G. O. H. B.
1094. herbivagus Say. H.
1099. ellipsis Lec. H.
1109. fraternus Lec. ? H.
1110. funestus Lec. H.
1111. oblitus Lec. H.
...... n. sp. H.
1125. Selenophorus pedicularius Dej. M.
1125. semiopacus, var. O.
1144. Stenolophus flavipes Lec. B.
1158. Bradycellus rupestris Say. B.
1184. Anisodactylus consobrinus Lec. H.
1214. Pseudomorpha angustata Horn. M.

Family HALIPLIDÆ.

1229. Cnemidotus simplex Lec. B.

Family DYTISCIDÆ.

1243. Laccophilus decipiens Lec. M. B.
1251. mexicanus Aube. B.
...... Hydroporus undet. sp., near addendus Cr. B.
1389. Ilybius biguttalus Germ. O.
1396. Coptotomus interrogatus Fab. B.
1476. Eretes sticticus Linn. M.
1496*b*. Thermonectes latecinctus Lec. B.

Family HYDROPHILIDÆ.

1546. Helophorus linearis Lec. M.
1586. Hydrophilus triangularis Say. M.
1588. Tropisternus limbalis Lec. B.
1594. ellipticus Lec. M. B.
1600. Berosus punctatissimus Lec. B.
1602. miles Lec. B.
1619. Chætarthria pallida Lec. B.
1621. Laccobius agilis Rand. B.
1622. ellipticus Lec. M.
1624. Helochares carinatus Lec. B.
1626. nebulosus Say. B.
1634. diffusus Lec. B.

Family SILPHIDÆ.

1698. Necrophorus marginatus Fab. H.
1700. guttula Mots. H.
1705. Silpha truncata Say. H.
1706. lapponica Hbst. H.

Family STAPHYLINIDÆ.

...... Aleochara undet. sp. B.
2098. Quedius explanatus Lec. O.
2119. Creophilus villosus Grav. O.
2123. Staphylinus nigrellus Horn. O.
2178. Philonthus varians Payk. H.
undet. sp. B.
2251. Actobius pæderoides Lec. B.
2778. Apocellus analis Lec. ? B.

Family PHALACRIDÆ.

2992. Phalacrus penicillatus Say. O. H.
9874. conjunctus Casey. B.
2998. Olibrus striatulus Lec. O.
3002. pallipes Say. O. H.
...... Eustilbus sp., near nanulus Casey. B.

Family Coccinellidæ.

3041. Hippodamia 5-signata Kirby. H.
3043. lecontei Muls. H., summit and base.
3046. convergens Guer. H. B.
3051. parenthesis Say. O.
3064. Cycloneda sanguinea Linn. O. H.
3065*a*. Olla abdominalis Say. B.
...... Adalia humeralis Say., var. O.
3069. Cleis picta Rand. O.
...... Anatis lecontei Casey. O. H.
3078. Psyllobora 20-maculata Say. O.
3078*a*. tædata Lec. O. B.
3101. Hyperaspis fimbriolata Melsh. B.
3103. tæniata Lec. B.
3105. undulata Say. B.
3111. osculans Lec. B.
3142. Scymnus cinctus Lec. B.
3146. hæmorrhous Lec. O. B.
3157. lacustris Lec. O.
...... ardelis Horn. B.
...... undet. sp. B.

Family Erotylidæ.

3240. Erotylus boisduvali Chev. O.

Family Dermestidæ.

3418. Dermestes marmoratus Say. O. H.
3423. carnivorus Fab. B.
3440. Trogoderma simplex Jayne. B.
...... undet. sp. B.
3450. Cryptorhopalum apicale Mann. H. B.
3455. Orphilus glabratus Fab. H.

Family Histeridæ.

3494. Hister depurator Say. H.
3539. Epierus nasutus Horn. O.
3582. Saprinus alienus Lec. B.
3583. lugens Er. H. B.
3586. oregonensis Lec. O. H.
3607. vitiosus Lec. M.
3610. fimbriatus Lec. H. B.
3612. cærulescens Lec. B.

Family Nitidulidæ.

3733. Perthalycra murrayi Horn. O.

Family Trogositidæ.

3832. Alindria teres Melsh. B.
3835. Trogosita yuccæ Cr. B.
3838. Tenebrioides corticalis Melsh. O.
3841*a*. californica Horn. B.
3850. Calitys scabra Thunb. O.

Family Byrrhidæ.

3903. Limnichus analis Lec. B.

Family Parnidæ.

3920. Dryops productus Lec. O. B.
3924. suturalis Lec. B.

Family Heteroceridæ.

3965. Heterocerus collaris Kies. B.

Family Elateridæ.

4089. Chalcolepidius webbii Lec. B.
10035. behrensi Cand. M. B.
4128. Horistonotus simplex Lec. M.
4136. Esthesopus parcus Horn. M.
4137. dispersus Horn. M.
...... two undet. sp. B.
10052. Cryptohypnus cucullatus Horn. B.
4185. Monocrepidius vespertinus Fab. B.
4188. sordidus Lec. M.
4277. Ludius hepaticus Germ. B.
4306. Melanotus macer Lec. M.
4402. Athous scissus Lec. O.
...... Corymbites undet. sp. M.
4530. Euthysanius lautus Lec. O.

Family Buprestidæ.

4560. Gyascutus planicosta Lec. M. B.
4561. obliteratus Lec. M. B.
4564. Hippomelas sphenicus Lec. M.
4565. cælatus Lec. M. B.
4594. Poecilonota cyanipes Say. O.
4620. Melanophila atropurpurea Say. M. B.
4636. Chrysobothris octocola Lec. M. B.
4637. atabalipa Lap. M, (=*basalis*).
4639. femorata Fab., var. B.
4650. trinervia Kirby. O.
4653. debilis Lec. M. B.
4654. deleta Lec. M.
10078. mali Horn. O. M.
10085. merkelii Horn. M.
...... nearly related to mexicana, if not that species. O.
4667. Actenodes calcarata Chev. B.
4675. Polycesta velasco Lap. and Gory. M. B.
4677. Acmæodera amplicollis Lec. O.
4679. amabilis Horn. O.
4686. miliaris Horn. O. B.
4690. connexa Lec. O.
...... aliciæ Fall. B.
4705. guttifera Lec. B.

4708. Acmæodera 4-vittata Horn. O. M.
4710. gibbula Lec. M.
10100. stigmata Horn. B.
10101. bivulnera Horn. B.
...... New genus, n. sp. B.
...... Tyndaris n. sp. B.
4752. Agrilus couesii Lec. O.
10126. blandus Horn. O.
...... Taphrocerus sp. O.
4764. Pachyscelus purpureus Say. O.

Family LAMPYRIDÆ.

4767. Rhyncheros sanguinipennis Say. O.
4772. Lycostomus loripes Chev. O.
4811. Lucidota punctata Lec. O.
4815. Ellychnia corrusca Linn. O.
4817. Pyropyga fenestralis Melsh. B.
4872. Chauliognathus scutellaris Lec., var. O.
4970. Ditemnus obtusus Lec.? B.

Family MALACHIDÆ.

5002. Collops bipunctatus Say. O. H.
5004. 4-maculatus Fab., var. O.
5006. pulchellus Horn. B.
5010. laticollis Horn. O.
5023. Malachius biguttulus Horn. M.
5040. Anthocomus ventralis Horn. O.
...... undet. sp. B.
5055. Attalus morulus Lec. O.
5061. rufiventris Horn. B.
...... n. sp. B.
...... undet. sp., near trimaculatus Mots. B.
5109. Listrus senilis Lec. O. H.
Five undetermined species. O.

Family CLERIDÆ.

5131. Cymatodera puncticollis Bland. M.
5134. cylindricollis Chev. O.
5151. ovipennis Lec. M.
...... n. sp. O.
...... undet. sp. M.
5156. Trogodendron edwardsii Horn. B.
5158. Trichodes ornatus Say. O. H.
5173. Clerus abruptus Lec. O.
5192. Hydnocera subænea Spin. O.
5197. discoidea Lec. B.
...... n. sp. O.
5223. Enoplium humerale Horn. O.
5230. Necrobia rufipes Fab. B.
5232. violaceus Linn. H.

Family PTINIDÆ.

5338. Sinoxylon simplex Horn. M. B.
5340. sericans Lec. M.
5354. Amphicerus fortis Lec. M. B.

Family LUCANIDÆ.

5419. Platycerus depressus Lec. H.

Family SCARABÆIDÆ.

5442. Chœridium lecontei Harold. B.
5494. Atænius lobatus Horn. B.
5497. hirsutus Horn. M.
5502. desertus Horn. M.
...... haroldi Steinbeil. M. B.
10186. læviventris Horn. M.
5529. Aphodius vittatus Say. H.
5533. lividus Oliv. M.
5539. anthracinus Lec. O. H.
5556. subtruncatus Lec. H.
5581. Ochodæus biarmatus Lec. M.
5612. Trox scutellaris Say. M.
5616. suberosus Fab. M.
5617. punctatus Germ. B.
5618. tuberculatus De G. O.
5620. sonoræ Lec. O. H. M.
5633. Glaresis mendica Horn. M.
5692. Macrodactylus uniformis Horn. O.
5697. Orsonyx anxius Lec. B.
5701. Diplotaxis popino Casey. M.
5706. tristis Kirby. M.
5721. carbonata Lec. M.
5724. punctata Lec. M.
...... four undet. sp. M.
5806. Listrochelus disparilis Horn. O.
5809. scoparius Lec. M.
5816. timidus Horn. M.
5822. Polyphylla decemlineata Say. O.
5842. Strigoderma arboricola Fab. O.
5846. Pelidnota lugubris Lec. M.
5859. Cyclocephala longula Lec. M.
5865. dimidiata Burm. M. B.
5866. manca Lec. O.
5870. Ligyrus ruginasus Lec. M.
10276. Aphonides dunniana Rivers. M.
5883. Strategus julianus Burm. M.
5908. Euphoria fascifera Lec. M.
5911. inda Linn. O.

Family SPONDYLIDÆ.

5947. Parandra polita Say. B.

Family CERAMBYCIDÆ.

5952. Mallodon mandibularis Harold. O.
5957. Derobrachus geminatus Lec. M. B.
...... undet. sp. near Axestinus. M.
6036. Osmidus guttatus Lec. B.
6049. Romaleum simplicicolle Hald. M.
6067. Elaphidion tenue Lec. M.
6076. Aneflus protensus Lec. M.
6105. Rhopalophora longipes Say. O.
6113. Rosalia funebris Mots. O.
6119. Dendrobias quadrimaculatus Dup. M.
6122. Stenaspis solitaria Say. M.
6126. Tragidion annulatum Lec. O.
6127*a*. fulvipenne Say. O.
6135. Aethecerus latecinctus Horn. B.
6158. Sphænotheous suturalis Lec. B.
6166. Stenosphenus debilis Horn. O.
6249. Pachyta armata Lec. O.
6490. Mecas cana Newm. O.
6513*c*. Tetraopes oregonensis Lec. O.
Two undetermined species of uncertain genera. M. B.

Family CHRYSOMELIDÆ.

6574. Lema nigrovittata Guer. B.
6582. Euryscopa lecontei Cr. M. B.
...... parvula Jac. M. B.
6584. Coscinoptera æneipennis Lec. M.
6588. canella Lec. B.
6589. mucorea Lec. M.
6594. Megalostomis major Cr. M.
6596*b*. Babia tetraspilota Lec. O.
6599. Saxinis saucia Lec. O. B.
10346. sonorensis Jac. O.
6600. Urodera crucifera Lec. O.
6601. Chlamys plicata Fab. B.
6622. Cryptocephalus leucomelas Suffr. O.
...... n. sp. O.
6653. Pachybrachys xanti Cr. M. B.
6660. abdominalis Say. B.
6690. atomarius Melsh. O.
...... thoracicus Jac. B.
...... two n. sp. B.
6706. Monachus guerini Perb. B.
6707. Diachus auratus Fab. O.
6754. Metachroma californica Cr. B.
6796. Chrysomela conjuncta Rog. O.
6800. disrupta Rog. O.
6821. auripennis Say. O.
6881*a*. Diabrotica tenella Lec. O. B.
6916*a*. Monoxia angularis Lec. O.
6916. obtusa Lec., var. O.
10407. debilis Lec. B.

6929. Œdionychis lustrans Cr. M.
6933. lugens Lec. O.
6949. Disonycha 5-vittata Say. O.
10416 crenicollis Say. B.
7001. Systena tæniata Say., var. M.
7001 tæniata, var. mitis Lec. B.
7001. tæniata, var. pallidula Boh. B.
10438. Longitarsus vanus Horn. B.
10452. Glyptina atriventris Horn. B.
7028. Phyllotreta lewisii Cr. B.
10458. pusilla Horn.
10463. Chætocnema ectypa Horn. B.
7068. Microrhopala cyanea Say. O.
7073. Odontota collaris Say. O.
7074. omogera Cr. O.

Family Bruchidæ.

7133. Bruchus pruininus Horn. B.
7137. prosopis Lec. B.
7143. bisignatus Horn B.
7149. amicus Horn. B.

Family Tenebrionidæ.

7168. Edrotes ventricosus Lec. B.
7171. Triorophus lævis Lec. M.
7182. Eurymetopon rufipes Esch. B.
7183. emarginatum Casey. B.
7184. dubium Casey. M.
7185. convexicolle Lec. M.
7189. serratum Lec. B.
..... undet. sp. M.
7191. Emmenastus longulus Lec. M. B.
7193. subopacus Horn. M.
7195. ater Lec. O. H.
7196. acutus Lec. O.
..... convexus Lec., var. O. H.
7302. Epitragus canaliculatus Say. O.
10507. fusiformis Casey. O. M.
7210 Chilometopon abnorme Horn. B.
7238. Cryptoglossa verrucosa Lec. B.
7243. Centrioptera variolosa Horn. M.
7280. Asida consobrina Horn. O.
7284. marginata Lec. M.
7287. macra Horn. H.
10525. wickhami Horn. B.
..... n. sp. O.
7298. Coniontis ovalis Esch. O.
7316. Eleodes obscura Say. H.
7322. carbonaria Say. O.
7323. obsoleta Say. H.
7324. quadricollis Esch. H.

7325. Eleodes humeralis Lec. H.
7327. extricata Say. O. H.
7329. armata Lec. M. B.
7339. nigrina Lec. H.
..... undet. sp. near nigrina Lec. H.
7351. consobrina Lec. H.
7353. planipennis Lec. H.
7365. Embaphion contusum Lec. H.
7379. Argoporis costipennis Lec. O.
10568. alutacea Casey. M.
7392. Nyctobates subnitens Horn. B.
7394*a*. Iphthimus sublævis Bland. H.
7394*b*. lewisii Horn. H.
7398. Cœlocnemis magna Lec. O. H.
7431. Blapstinus sulcatus Lec. B.
7433. dilatatus Lec. B.
7439. vestitus Lec. M. B.
7440. longulus Lec. M.
7450. Notibius puberulus Lec. B.
10614. Ulus elongatulus Casey. M.
10617. Tribolium confusum Duv. O. H.
...... Platydema n. sp. O.
7568. Helops arizonensis Horn. M.

Family Cistelidæ.

7597. Hymenorus, near confertus Lec. B.
7599. punctatissimus Lec B.
10656. spinifer Horn. M.
10659. ruficollis Champ. M.
10673. indutus Casey. M.

Family Monommidæ.

7644. Hyporhagus opuntiæ Horn. M.

Family Œdemeridæ.

7730. Ditylus obscurus Lec. O.
7739. Oxacis cana Lec. M.
7749. lucana Lec. B.
...... subfusca. B.

Family Mordellidæ.

7771. Anaspis pusio Lec. O.
...... n. sp. B.
...... undet. sp., probably new. B.
7780. Mordella scutellaris Fab. O.
7863. Mordellistena angusta Lec. O.
...... two undet. sp. B.

Family ANTHICIDÆ.

7919. Notoxus bifasciatus Lec. M.
7922. calcaratus Horn. O.
...... curvitrichus Casey. B.
7948. Anthicus confinus Lec. B.
7968. nanus Lec. ? B.

Family MELOIDÆ.

8025. Nemognatha apicalis Lec. O.
8038. punctipennis Lec. B.
8038*v*. punctipennis Lec. O.
8041. cribricollis Lec. B.
8066. Macrobasis lauta Horn. M.
8067. tenella Lec. M.
...... Epicauta, n. sp. B.

Family RHIPIPHORIDÆ.

8178. Rhipiphorus cruentus Germ. O.
8178. cruentus Germ., var. B.
...... Myodites, sp. M. B.

Family OTIORHYNCHIDÆ.

8248. Eupagoderes decipiens Lec. B.
8250. argentatus Lec. B.
8253. varius Lec. B.
8262. Orimodema protracta Horn. O.
8294. Thricolepis inornata Horn. O.
8301. Eucyllus vagans Horn. M. B.
8314. Pandeletejus hilaris Hbst. O.
8317. Cyphus lautus Lec. B.

Family CURCULIONIDÆ.

8398. Apion ventricosum Lec. B.
...... undet. sp. B.
8500. Lixus perforatus Lec. M.
10860. Dinocleus denticollis Casey. M.
8521. Cleonus virgatus Lec. B.
8558. Smicronyx fulvus Lec. O.
8559. sordidus Lec. O.
8571. Endalus limatulus Gyll. B.
8669. Anthonomus canus Lec. B.
11012. ornatulus Dietz. B.
11040. Elleschus angustatus Dietz, var. B.
8701. Sibynes fulvus Lec. ? (very dark form). B.
8725. Conotrachelus similis Boh. M.
8835. Cœliodes acephalus Say. O.
11090. Baris dilatata Casey. B.
8886. Pseudobaris farcta Lec O.
8960. Balaninus uniformis Lec. M.

Family Calandridæ.

9014. Yuccaborus frontalis Lec. M.
9026. Cossonus concinnus Boh. O. H.

Family Scolytidæ.

9200. Hylurgops rugipennis Mann. O.

SUMMARY OF SPECIES OF COLEOPTERA.

Cicindelidæ	4
Carabidæ	54
Halipldiæ	1
Dytiscidæ	7
Hydrophilidæ	12
Silphidæ	4
Staphylinidæ	8
Phalacridæ	5
Coccinellidæ	20
Erotylidæ	1
Dermestidæ	6
Histeridæ	8
Nitidulidæ	1
Trogositidæ	5
Byrrhidæ	1
Parnidæ	2
Heteroceridæ	1
Elateridæ	15
Buprestidæ	33
Lampyridæ	7
Malachidæ	17
Cleridæ	14
Ptinidæ	3
Lucanidæ	1
Scarabæidæ	41
Spondylidæ	1
Cerambycidæ	21
Chrysomelidæ	45
Bruchidæ	4
Tenebrionidæ	51
Cistelidæ	5
Monommidæ	1
Œdemeridæ	4
Mordellidæ	7
Anthicidæ	5
Meloidæ	7
Rhipiphoridæ	3
Otiorhynchidæ	8
Curculionidæ	17
Calandridæ	2
Scolytidæ	1
Total number of species	453

II. LIST OF LEPIDOPTERA.

The numbers and nomenclature are those of Smith's check-list of 1903.

Abbreviations: O. for Oak Creek Canyon; H. for Humphrey's Peak at base; M. for Martinez (Congress Junction); and B. for Bill Williams Fork.

For valuable aid in the determination of some of the most difficult species, the author is indebted to Professors John B. Smith and C. H. Fernald and Dr. Henry Skinner.

Family NYMPHALIDÆ.

1. Danais plexippus Linn. B.
2*a*. strigosa Bates. B.
10. Euptoieta claudia Cram. B.
15. Argynnis nitocris Edw. O.
20. nausicaä Edw. O.
102. Melitæa perse Edw. M.
113. definita Aaron. M.
117. nympha Edw. H.
127. Phyciodes camillus Edw. O. H.
128. mylitta Edw. O. H.
137. Synchloe lacinia Geyer. M.
143. Grapta satyrus Edw. O.
144. hylas Edw. O.
148. zephyrus Edw. O. H.
153. Vanessa antiopa Linn. H.
154. californica Bdv. H., base and summit.
158. Pyrameis cardui Linn. B.
159. caryæ Hbn. H.
228*e*. Satyrus olympus Edw. O.

Family ERYCINIDÆ.

256. Lemonias mormo Feld. M.
258. cythera Edw. M.
261. palmerii Edw. M.
265. Calephelis australis Edw. B.

Family LYCÆNIDÆ.

272. Thecla halesus Cram. B.
283. melinus Hbn. B.
375. Lycæna melissa Edw. O. H.
378. acmon Db. and Hew. B.
383*e*. cinerea Edw. O.
384. amyntula Bdv. O.
387. isola Reak. B.
389. cyna Edw. B.
393. exilis Bdv. B.
394. marina Reak. O. B.

Family PAPILIONIDÆ.

406. Pieris occidentalis Reak. H., base and summit.
407. protodice Bd. & Lec. B.
411*a*. Nathalis irene Fitch. B.
423. Catopsilia eubule Linn. B.
433. Colias cæsonia Stoll. O. B.
438. eurytheme Bdv. O. B.
438*a*. ariadne Edw. B.
453. Terias mexicana Bdv. B.
454. nicippe Cram. M. B.
469. Papilio philenor Linn. B.
470. acauda Oberth. B.
473. bairdii Edw. H.
485. daunus Bdv. O.

Family HESPERIDÆ.

506. Pamphila taxiles Edw. O.
535. phylæus Dru. B.
539. sabuleti Bdv. B.
551. vestris Bdv. O.
590. eufala Edw. near B.
610. Pyrgus ericetorum Bdv. B.
613. tessellata Scudd. O. B.
631. Nisoniades petronius Lint. O.
632. horatius Scudd. & Burg. O.
633. terentius Scudd. O.
638. pacuvius Lint. O.
640. clitus Edw. O.
641. funeralis Scudd & Burg. B.
645. Systasea pulverulenta Feld. M.
654. Pholisora libya Scudd. B.
661. Eudamus pylades Scudd. O.
677. proteus Linn. B.
691. Erycides amyntas Fabr. B.

Family SPHINGIDÆ.

702. Hemaris thetis Bdv. O.
729. Deilephila lineata Fabr. O. H. M. B.
737. Pholus achemon Dru. O.
754. Phlegethontius quinquemaculata Haw. O. M. B.
766. Sphinx chersis Hbn. O.

Family SYNTOMIDÆ.

862. Lycomorpha grotei Pack. O.

Family ARCTIIDÆ.

926. Eubaphe ostenta Hy. Edw. O.
999. Lerina incarnata Wlk. O.
1028. Halisidota otho Barnes. O.
1031. Hemihyalea labecula Grt. O.

Family Pericopidæ.

1046*b*. Gnophæla vermiculata G. & R. O.

Family Noctuidæ.

1243. Caradrina meralis Morr. O.
1245. extimia Wlk. O. B.
1247. leucorena Sm. B.
1266. Perigea veterata Sm. O.
1295. Hadena longula Grt. O.
1317. impulsa Gn. O.
1318. devastatrix Brace. O.
1319. exulis Lef. O.
1321. arctica Bdv. O.
1342. auranticolor Grt. O.
1359. indirecta Grt. O.
1382. characta Grt. O.
1444. Pyrophila pyramidoides Linn. O.
1452. Laphygma frugiperda S. & A. B.
1453. flavimaculata Harv. B.
1474. Oncocnemis dayi Grt. O.
1560. Rhynchagrotis placida Grt. O.
1563. alternata Grt. O.
1565. cupidissima Grt. O.
1566. trigona Sm. O.
1626. Agrotis ypsilon Rott. B.
1639*a*. Peridroma saucia Hbn. O.
1647. Noctua smithii Snell. O.
1728. Feltia annexa Tr. B.
1783. Euxoa perfusca Grt. O.
1825. sessile Sm. O.
1831. messoria Har. O.
1888. insulsa Wlk. O.
1900. basalis Grt. O.
1948. Ufeus satyricus Grt. O.
2034. Mamestra noverca Grt. O.
2058*a*. illaudabilis Grt. O.
2080. Barathra occidenta Grt. O.
2099. Xylomiges dolosa Grt. O.
2194. Leucania farcta Grt. O.
..... undet. sp. O.
2231. Tæniocampa incincta Morr. O.
2504. Heliothis armiger Hbn. O. H. B.
2612. Melicleptria villosa Grt. O.
2812. Pleonectyptera finitima Sm. O.
2813. incusalis Grt. B.
2914. Acontia areli Strck. O.
2931. meskei Sm. B.
..... Spragueia urtricina ——. B.
2991. Cissisa ægrotata Hy. Edw. B.
2995. Drasteria crassiuscula Harv. O.
2997. cærulea Grt. O.

3008. Melipotis nigrescens G. & R. B.
3010. perlæta Hy. Edw. B.
3015. jucunda Hbn. B.
3020. Cirrhobolina mexicana Behr. B.
3078. Catocala violenta Hy. Edw. O.
3085. aholibah Strck. O.
3092. mariana Hy. Edw. O.
3099. stretchii Behr. O.
3103. junctura Wlk. O.
3122. subnata Grt. O.
3143. Toxocampa victoria Grt. O.
3191. Heteranassa fraterna Sm. B.
3198. Matigramma rubosuffusa Grt. B.
3202. Yrias clientis Grt. B.
3203. strigalis Sm. B.
3204. volucris Grt. B.
3207. albiciliatus Sm. B.
3235. Erebus odora Linn. B.
3280. Renia near sobrialis Wlk. O.

Family GEOMETRIDÆ

3691. Cœnocalpe magnoliata Gn. O.
3707. Emplocia inconstans Geyer. O.

Family PYROMORPHIDÆ.

4461. Triprocris constans Hy. Edw. O.

Family SESIIDÆ.

4514. Alcathoe korites Druce. O.
4533. Ægeria tibialis Har. O.
4545. Sesia giliæ Hy. Edw. O.
4577. tecta Hy. Edw. O.

Family PYRALIDÆ.

4697. Evergestis obliquilis Grt. O.
4726. Loxostege commixtalis Wlk. O.

SUMMARY OF SPECIES OF LEPIDOPTERA.

Nymphalidæ	19	Arctiidæ	4
Erycinidæ	4	Pericopidæ	1
Lycænidæ	10	Noctuidæ	66
Papilionidæ	13	Geometridæ	2
Hesperidæ	18	Pyromorphidæ	1
Sphingidæ	5	Sesiidæ	4
Syntomidæ	1	Pyralidæ	2
		Total number of species	150

III. LIST OF DIPTERA.

For indispensable services in the preparation of this list, the writer is under obligations to his associate and fellow student, Dr. Chas. F. Adams.

Abbreviations for localities: O., for Oak Creek canyon; H., for Humphrey's Peak; M., for Martinez (Congress Junction); and B., for Bill Williams Fork.

Family Mycetophilidæ.

Macrocera diluta Adams, n. sp. (June, 1903). O.

Family Culicidæ.

Culex affinis Adams, n. sp. (June, 1903). O.
apicalis Adams, n. sp. (June, 1903). O.
particeps Adams, n. sp. (June, 1903). O.
tarsalis Coq. B.
triseriatus Say. O.
Anopheles maculipennis Meig. O.
pseudopunctipennis Theobald (?) O. B.

Family Psychodidæ.

Pericoma sp. O.
Sycorax lanceolata Kincaid. O.

Family Tipulidæ.

Erioptera caloptera Say. O.

Family Dixidæ.

Dixa clavata Loew. O.

Family Simuliidæ.

Simulium notatum Adams, n. sp. B.

Family Stratiomyidæ.

Euparyphus albipilosus Adams, n. sp. (June, 1903).
Odontomyia binotata Loew. O. B.
Nemotelus glaber Loew. B.
simplex Will. O.
unicolor Loew. B.

Family Tabanidæ.

Chrysops pachycera Will. B.
Silvius quadrivittatus Say. B.
Tabanus punctifer O. S. B.
vivax O. S. B.

Family Mydasidæ.

Mydas abdominalis Adams, n. sp. M.

Family ASILIDÆ.

Stichopogon trifasciatus Say. O.
Deromyia angustipennis Loew. O. H.
Dasyllis posticata Say. O.
Promachus rufipes Wied. O.
Erax maculatus Macq. B.

Family BOMBYLIIDÆ.

Exoprosopa dodrans O. S. H.
fasciata Macq. O. H.
Dipalta serpentina O. S. H.
Argyramœba simsoni Fabr. O.
Anthrax fulviana Say. H.
lateralis Say. O. H.
sinuosa Wied. O. H.
Phthiria consors O. S. O. H.
sulphurea Loew. O. H.
Geron subauratus Loew. O.
Toxophora pellucida Coq. O.
Dolichomyia gracilis Will. O.

Family THEREVIDÆ.

Psilocephala aldrichii Coq. H.
lateralis Adams, n. sp. B.
occipitalis Adams, n. sp. B.
Thereva anomala Adams. n. sp. O.
diversa Coq. O.

Family SCENOPINIDÆ.

Scenopinus electa Adams, n. sp. B.
mirabilis Adams, n. sp. B.
Pseudotrichia griseola Coq. M.

Family ACROCERIDÆ.

Oncodes melampus Loew. H.

Family EMPIDÆ.

Microdromia empiformis Say. O.

Family DOLICHOPODIDÆ.

Polymedon nimius Ald. O.
two species, probably new. O.
Macellocerus ornatus Ald. O.
Gnamptosilopus infurnatus Ald. O.
Hydrophorus near eldoradensis Wh. O.
Tachytrechus near angustipennis Loew. O.
Pelastoneurus, probably n. sp. B.
Dolichopus sp. O.
myosotus O. S. O.
Asyndetus two sp. B.

Hercostomus near latipes Ald. B.
Lyroneurus sp. B.
Chrysotus, five undet. sp. O. B.
Porhhyrops sp. O.
Paraclius sp. B.
Sympycnus sp. O.
Five species of undet. genus. O. B.
Psilopus melampus Loew. O.
species, probably new. O.

Family SYRPHIDÆ.

Chrysotoxum derivatum Walk. H.
Paragus tibialis Fall. O. B.
Nausigaster geminata Town. M.
punctulata Will. O.
scutellaris Adams, n. sp. M.
Chrysogaster bellula Will. O. B.
Melanostoma stegnum Say. H.
Cataboma pyrastri Linn. H.
Eupeodes volucris O. S. H. B.
Syrphus americanus Wied. H.
arcuatus Fall. H.
creper Snow. H.
lotus Will. H.
ribesii Linn. H.
ruficauda Snow. H.
Mesogramma marginata Say. H. B.
Allograpta obliqua Say. O. H.
Baccha obscuricornis Loew. O.
Myiolepta varipes Loew. H.
Volucella anna Will. O.
esuriens Fabr. O.
haagii Jænn. O.
isabelliana Will. O. B.
Copestylum marginatum Say. O.
Eristalis latifrons Loew. H. M. B.
vinetorum Fabr. B.
Helophilus latifrons Loew. B.
vinetorum Fabr. B.
Xylota fraudulosa Loew. O.
Syritta pipiens Linn. O. B.
Chrysochlamys crœsus. O. S. O.
Spilomyia kahli Snow. O.
Sphyxomorpha snowi Adams, n. sp. B.

Family CONOPIDÆ

Conops gracilis Will. B.
sylvosus Will. O.
xanthopareus Will. O.
Physocephala affinis Will. O.
Oncomyia abbreviata Loew. O.
loraria Loew. O.

Zodion fulvifrons Say. O.
obliquefasciata Macq. O.
parvus Adams, n. sp. (June, 1903). O.
pygmæum Will. O.
scapularis Adams, n. sp. (June, 1903). O.

Family PHORIDÆ.

Phora, probably n. sp., O.

Family ŒSTRIDÆ.

Cuterebra americana Fabr. O.

Family TACHINIDÆ

Cistogaster immaculata Macq. O.
Gymnosoma fuliginosa Desv. O.
Phorantha occidentis Walk. B.
Wahlbergia arcuata Say. O.
Plagiprospherysa parvipalpis v. d. W. O.
Paraphyto opaca Coq. O.
Chætogædia crebra v. d. W. O.
Epigrimyia lucens Town. O.
occidentalis Coq. O.
Heteropterina nasoni Coq. O.
Pachyophthalmus floridensis Town. O.
signatus Meig. O.
Vanderwulpia atrophopodoides Town. B.
Cenosoma signifera, v. d. W. B.
Metachæta helymus Walk. B.
Hilarella decens Town. M.
Senotainia rubriventris Macq. O. H.
Exorista pyste Walk. O.
undet. sp.
Leucostoma atra Town. O.
Siphona geniculata De G. O. H.
Panzeria radicum Fall. O. H.
Microphthalma disjuncta Wied. O. H.
Gonia capitata De G. O.
undet. sp.
Peleteria robusta Wied. O. H.
tessellata Fabr. O. H.
Archytas analis Fabr. O.
hystrix Fabr. O.
lateralis Macq. O.
Echinomyia algens Wied. O. H.
dispar v. d. W. O.
Epalpus bicolor Will. H.
Hystricia soror Will. O.
Dejeania corpulenta Wied. O.
Paradejeania rutilioides Jænn. O.
Jurinella ambigua Macq. O. H.

Family SARCOPHAGIDÆ.

Phrissopoda præceps Wied. O.

Family MUSCIDÆ.

Musca domestica Linn. O. H. M. B.
Compsomyia macellaria Fabr. O. H.

Family ANTHOMYIDÆ.

Limnophora, two undet. sp. O. B.
Lispa sp. B.

Family SCIOMYZIDÆ.

Tetanocera pictipes Loew. O.
saratogensis Fitch. O.

Family SCATOPHAGIDÆ.

Scatophaga ? sp. ? O.

Family TRYPETIDÆ.

Stenopa vulnerata Loew. O.
Spilographa flavonotata Macq. O.
Plagiotoma obliqua Say. B.
Eutreta sparsa Loew. O.
Icterica fasciata Adams, n. sp. B.
Ensina humilis Loew. B.
Tephritis finalis Loew. O.
fucata Fabr. B.
Euaresta bella Loew. B.
bellula Snow. B.
Urellia abstersa Loew. B.
bisetosa Coq. B.
conjuncta Adams, n. sp. B.
flava Adams. n. sp. B.
mevarna Walk. B.
nigricornis Coq. B.
vicina v. d. W. B.

Family ORTALIDÆ.

Anacampta latiuscula Loew. B.
Stictocephala cribellum Loew. B.
Chaetopsis ænea Wied. B.
Euxesta spoliata Will. B.

Family SAPROMYZIDÆ.

Pachycerina verticalis Loew. O.
Sapromyza sp. O.

Family SEPSIDÆ.

Sepsis violacea Meig. O. H.

Family Ephydridæ.

Paralimna appendiculata Loew. O.
Parydra quadrituberculata Loew. O.
Brachydeutra argentata. Walk. O.
Ochthora mantis DeG. O.
Notiphila sp. B.

Family Agromyzidæ.

Cacoxenus sp. O.
Agromyza sp. B.

Family Oscinidæ.

Chrolops assimilis Macq. O.
pullipes Coq. O.
halteralis Adams, n. sp. (June '03.) O.
Elachiptera bilineata Adams, n. sp. O.

SUMMARY OF SPECIES OF DIPTERA.

Mycetophilidæ	1	Conopidæ	11
Culicidæ	7	Phoridæ	1
Psychodidæ	2	Œstridæ	1
Tipulidæ	1	Tachinidæ	36
Dixidæ	1	Sarcophagidæ	1
Simuliidæ	1	Muscidæ	1
Stratiomyidæ	5	Anthomyidæ	3
Tabanidæ	4	Sciomyzidæ	2
Mydasidæ	1	Scatophagidæ	1
Asilidæ	5	Trypetidæ	17
Bombyliidæ	12	Ortalidæ	4
Therevidæ	5	Sapromyzidæ	2
Scenopinidæ	3	Sepsidæ	1
Acroceridæ	1	Ephydridæ	5
Empidæ	1	Oscinidæ	4
Dolichopodidæ	29	Total species	201
Syrphidæ	32		

IV. LIST OF HEMIPTERA.

For valuable assistance in the determination of the species in this list, the author is chiefly indebted to E. P. Van Duzee. His grateful acknowledgments are also due to Otto Heidemann and Prof. E. D. Ball.

I. Sub-order *HETEROPTERA*.

Numbers from Uhler's check-list. Abbreviations for localities: O. for Oak Creek canon; H. for Humphrey's Peak at base; B. for Bill Williams Fork; M. for Martinez (Congress Junction).

Family Cydnidæ.

75. Cyrtomenus mirabilis Perty. O.

Family Pentatomidæ.

168. Podisus crocatus Uhl. H.
192. Brochymena obscura H. S. M.
223. Cosmopepla carnifex Fab. O.
247. Euschistus servus Say. O.
284. Pentatoma sayi Stal. B.
300. Thyanta custator Fab. M. B.
314. Murgantia histrionica Hahn. O. Also at Ash Fork.
336. Nezara hilaris Say. O.

Family Coreidæ.

446. Mozena lineolata H. Schf. M. B.
447. (near) lunata Burm. O. B.
461. Archimerus calcarator Fab. O.
501. Narnia pallidicornis Stal. M.
507. Chelinidea vittigera Uhl. B.
517. Catorhintha selector Stal. B.
564. Alydus eurinus Say. O.
566. Megalonotus 5 spinosus Say. O.
587. Harmostes reflexulus Stal. B.
595. Corizus hyalinus Fab. B.
599. bohemani Sign. O.
601. lateralis Say. B.
606. Leptocoris trivittatus Say. O.

Family Berytidæ.

582. Jalysus spinosus Say. B.
583. Pronotacantha annulata Uhler. B.

Family Lygæidæ.

...... Nysius minutus Uhl. O.
618. californicus Stal. O. H. B.
639. Geocoris pallens Stal. O.

678. Ozophora picturata Uhl. O.
...... Scalopostethus thomsoni Reut. O.
...... Ptochiomera, n. sp. O.
743. Lygæus bicolor H. Schf. B.
752. reclivatus Say. O. M.
753. turcicus Fab. M. B.
...... melanopleurus Uhl. O.
...... var. brachypterus Uhl. O.
759. Oncopeltus fasciatus Dal. B.

Family Largidæ.

765. Largus cinctus H. Schf. O.
766. succinctus Linn. O. B.
773. Arhaphe carolina H. Schf. O.

Family Capsidæ.

...... Resthenia sp. O.
881. Lygus pratensis Linn. O. B.
902. Pœciloscytus basalis Reut. B.
...... Halticotoma valida Uhl. Ms. O.
...... Coquillettia insignis Uhler. O.
989. Macrocoleus coagulatus Uhl. H.
...... Psallus sp. O.

Family Phymatidæ.

1118. Phymata fasciata Gray. O. B.

Family Nabidæ.

1133. Pagasa nitida Stal. B.
1144. Coriscus ferus Linn. O. B.
1147. punctipes Reut. B.

Family Reduviidæ.

1152. Sinea diadema Fab. O. B.
1156. defecta Stal. O.
...... rileyi Montd. M.
1172. Atrachelus cinereus Fab. B.
1187. Milyas zebra Stal. O. H.
1209. Pindus socius Uhl. M. B.
1214. Apiomerus crassipes Fab. O.

Family Limnobatidæ.

1300. Limnobates lineata Say. B.

Family Hydrobatidæ.

1302. Hygrotrechus remigis Say. H.

Family Veliidæ.

...... Rhagovelia sp.? H. B.

Family SALDIDÆ.

1337. Salda polita Uhler. B.

Family GALGULIDÆ.

1356. Pelogonus americanus Uhler. B.
1357. Gelastocoris oculatus Fabr. O. H. M. B.

Family NAUCORIDÆ.

1365. Ambrysus melanopterus Stal. B.

Family BELOSTOMATIDÆ.

1373. Zaitha anurus H. Schf. H. B.

Family CORISIDÆ.

...... Corisa undet. sp. B.

II. SUB-ORDER *HOMOPTERA*.

Abbreviations for localities: O., for Oak Creek canon; H. for Humphrey's Peak; B. for Bill Williams Fork; M. for Martinez.

Family CICADIDÆ.

Cicada transversa Walk. M. B.
vitripennis Say. B.

Family MEMBRACIDÆ.

Ceresa taurina Fitch. O.
concinna Fowl. ? B.
Stictocephala inermis Fab. O.
rubrovitta Walk. O. B.
Telamona undet. sp. O.

Family FULGORIDÆ.

Scolops uhleri Ball. O.
Œcleus snowi Ball, n. sp. B.

Family CERCOPIDÆ.

Aphrophora irrorata Ball. O.
Philaronia bilineata Say. O.
abjecta Uhler. O.
Clastoptera xanthocephala Germ. O. H.

Family TETTIGONIDÆ.

Oncometopia costalis Fabr. O.
Homalodisca liturata Ball. B.
Tettigonia atropunctata Sign. O.
Diedrocephala mollipes Say. B.
Helochara communis Fitch. O.
Gypona melanota Spangb. O.

Family Jassidæ.

Phlepsius spatulatus Van Duzee. B.
Jassus clitorius Say. O.
Thamnotettix belli Uhler. O.

Family Psyllidæ.

Livia vernalis Fitch.
Aphalara, sp.
Psyllid, new species and probably new genus.

SUMMARY OF SPECIES OF HEMIPTERA

Suborder Heteroptera.		Suborder Homoptera.	
Cydnidæ	1	Cicadidæ	2
Pentatomidæ	8	Membracidæ	5
Coreidæ	13	Fulgoridæ	2
Berytidæ	2	Cercopidæ	4
Lygæidæ	12	Tettigonidæ	6
Largidæ	3	Jassidæ	3
Capsidæ	7	Psyllidæ	3
Phymatidæ	1	Total number of species	91
Nabidæ	3		
Reduvidæ	7		
Limnobatidæ	1		
Hydrobatidæ	1		
Veliidæ	1		
Saldidæ	1		
Galgulidæ	2		
Naucoridæ	1		
Belostomatidæ	1		
Corisidæ	1		

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CONTENTS:

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KANSAS UNIVERSITY SCIENCE BULLETIN.

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NOTES ON AND DESCRIPTIONS OF NORTH AMERICAN DIPTERA.

BY C. F. ADAMS.

IN presenting this paper I have, as usual, to thank Drs. F. H. Snow and S. W. Williston for kindnesses too numerous to mention. I take much pleasure, also, in acknowledging the loan of type material of Leptidæ by Prof. C. W. Johnson. To Profs. C. H. Fernald and R. K. Beattie thanks are due for material for study. To Prof. J. M. Aldrich I owe special thanks for references.

Anopheles pseudopunctipennis Theobald.

Specimens collected by Dr. F. H. Snow during August in Oak Creek canyon and along Bill Williams Fork, Arizona, agree with Theobald's description so far as it goes. The occiput is largely covered with upright black scales; there is a double median line of upright white scales which are replaced anteriorly between the eyes by long white hairs; the narrow occipital orbits are nearly bare, having a few long black hairs. The thorax has a double median white line on anterior part of mesonotum, extending a short distance backward. It appears to be a continuation of the similarly colored line of the head, but the scales are more cylindrical, *i. e.*, they are not broadened any at the apex. The remainder of the mesonotum and the scutellum are covered with light brown pile. If perfect specimens from the type locality should prove the head and thorax to be different from the above description, then the Arizona specimens will need another name.

Simulium notatum, n. sp.

Female: Yellow, with short yellow pile. Head yellow, covered with a thin grayish coat, mouth-parts and antennæ yellow, latter brownish on apical half, eyes black. Thorax, including scutellum and halteres, uniformly yellow. Abdomen yellow, dorsum with a row of four opaque, black spots; one specimen has the anterior part of the abdomen brownish, but this I believe to be due to desiccation. Legs yellow, last tarsal joint black, metatarsi with a row of short black spines on posterior margin, remaining joints with a few black, bristle-like hairs, tarsal claws simple. Wings hyaline, larger veins yellowish translucent. Length, 1.75 mm.

Two specimens; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

Mydas abdominalis, n. sp.

Male and female: Opaque black, abdomen except the first and last segments reddish yellow. Pile of face and front black, in some specimens intermixed with white ones, orbits of face and front grayish pollinose; antennæ slender, lamellæ truncate, sometimes with a dull reddish cast on inner side. Thorax opaque black, pile black, pleuræ with a very thin coat of gray pollen, halteres black. First abdominal segment, except narrow posterior border, opaque black, with black pile, the last segment in the female, and the hypopygium in the male, black, with black pile, in some specimens mixed with white, remainder of abdomen reddish yellow, both dorsally and ventrally, and with short yellowish pile. Legs black, hind femora with the usual spines beneath, the hind tibiæ with a strong apical spur, tip of latter and base of claws reddish. Wings uniformly dark brown, venation normal, posterior marginal cross-vein present. Length, 25–28 mm.

Congress Junction, Ariz. Collected by Dr. F. H. Snow.

XYLOPHAGUS.

TABLE TO THE SPECIES.

1. First joint of the antennæ much elongated................*longicornis* Loew.
   First joint of antennæ of usual length................................. 2
2. Legs in large part black.....................................*lugens* Loew.
   Legs in large part luteous.. 3
3. A yellow spot on each side near base of antennæ.............*reflectus* Walk.
   Destitute of such spot.. 4
4. Front entirely covered with grayish pollen.............................. 6
   Pollen of front reaching half-way, or more, from ocelli to antennæ....... 5
   Front shining, a narrow band of pollen near ocelli............*rufipes* Loew.
5. Second, third, fourth and fifth segments of abdomen rufous, lateral margins black.......................................*abdominalis* Loew.
   Abdomen blackish throughout, shining.......................*decorus* Will.
6. Tuft of white hairs on each side near base of antennæ.......*fasciatus* Walk.
   Destitute of such hairs... 7
7. Thorax dorsum univittate (polished black line)...........*triangularis* Say.
   Thorax bivittate (pollinose stripes)........................*gracilis* Will.
   Thorax, except sides, pollinose throughout..................*persequs* Walk.
   Thorax shining throughout..................................*nitidus*, n. sp.

Xylophagus nitidus, n. sp.

Female: Head black, occiput and cheeks shining, front and face covered with grayish pollen, antennæ dark, tip of second joint yellowish, that of the third joint black, first joint a little more than twice the length of second, third longer than the first and second together; proboscis yellow, palpi black; thorax shining, humeri, a narrow lateral line from humeri to base of wings, postalar callosities, pile and halteres yellowish, pleuræ with a very few pile; abdomen brownish black, shining, pile yellowish; coxæ and bases of femora light yellow, apical half of femore, four anterior tibiæ and tarsi brownish yellow, posterior tibæ, except each end, and their tarsi, dark brown; wings nearly hyaline, uniformly tinged with brown except on cross-veins, where it is darker. Length, 10 mm.

One specimen; Mt. Washington, New Hampshire. Geo. Dimmock.

CHRYSOPILA.

TABLE TO THE SPECIES.

1.	Black or brown in general color	2
	Testaceous or light colored	26
2.	Wings hyaline	3
	Wings hyaline, with an intense grayish tinge	*humilis* Loew.
	Wings wholly or in part fuscous or subfuscous	14
3.	Thorax with golden yellow, yellowish or pale hairs on tomentum	5
	Thorax with black pile	4
4.	Pile of abdomen yellow (Mexico)	*aterima* Will.
	Pile of abdomen black	*proxima* Walk.
5.	Femora black or brown, at least at base	6
	Femora yellow, blackish sometimes at apex	9
6.	Femora, except sometimes at extreme tip, wholly black	7
	Femora brown at base only	8
7.	Pile of vertex black	*tomentosa* Bigot
	Pile of vertex yellow (female)	*proxima* Walk.
8.	General color velvety black	*fasciata* Say.
	General color brownish black	*basilaris* Say.
9.	Apex of each abdominal segment yellow	10
	Apex of all abdominal segments not yellow	11
	Abdomen uniformly golden yellow	*testacipes* Bigot.
10.	The yellow of segments confined to ground color	*modesta* Loew.
	Yellow of segments confined to tomentum	*ornata* Say.
11.	Posterior femora brown at apex, 4 mm., Jamaica	*jamaicensis* John.
	Posterior femora entirely yellow, larger species	12
12.	First two abdominal segments largely yellow	13
	First two segments not yellow	*bella*, n. sp.
13.	Mesonotum with three dull testaceous stripes	*basalis* Walk.
	Mesonotum uniformly covered with golden yellow tomentum,	*invalida* Will.
14.	Thorax blackish pilose	15
	Thorax golden yellow, yellow, or largely light pilose	19
15.	Legs entirely black	16
	Legs not entirely black	17
16.	Wings with two dark brown spots on costal margin (St. Vincent, West Indies)	*atra* Will.
	Wings without such spots	*anthracina* Will.
17.	Hind border of each abdominal segment testaceous	*trifasciata* Walk.
	Hind border of each abdominal segment not testaceous	18
18.	Second abdominal segment broadly silvery villose at base	*nigra* Bell.
	Second segment not so marked	*velutina* Loew.
19.	Thorax golden yellow pilose or tomentose	20
	Thorax pale yellow pilose or tomentose	24
20.	Wings infuscated near tip only, 5 mm. (Mexico)	*puella* Will.
	Wings otherwise infuscated	21

21. Wings uniformly subfuscous 22
Wings darkest along the veins .... *thoracica* Say.
22. Pile of cheeks black (male), and white (female) .... *lucifera*, n. sp.
Pile of cheeks yellow or golden yellow 23
23. Tibiæ brownish black (Mexico) .... *mexicana* Bell.
Tibiæ yellow .... *flavibarbis*, n. sp.
24. All veins distinctly clouded with brown, 8–12 mm .... *fœda* Loew.
A large subquadrate spot in center, and sometimes on base, of wing brown .... *quadrata* Say.
Wings slightly infuscated at tip .... *apicalis* v. d. Wulp.
Wings uniformly subfuscous .... *propinqua* Walk.
Stigma and cross-veins only clouded 25
25. Thorax brownish, with an obsolete, dorsal stripe of a darker shade, 5–6 mm .... *griffithi* John.
Mesonotum opaque brown, with lateral margins and three median narrow stripes lighter colored, 7 mm. (Mexico) .... *latifrons* Will.
26. Wholly yellow .... *flavida* Bigot.
Not wholly yellow 27
27. Wings wholly or in part fuscous 28
Wings hyaline, apex grayish 30
28. Wings with central quadrate spot .... *quadrata* Say.
Wings without such spot 29
29. Wings uniformly infuscated (Mexico) .... *plebeia* Will.
Wings fuscous on distal part (Mexico) .... *nana* Will.
30. Wings broad and rounded .... *rotundipennis* Loew.
Wings not broad and rounded (West Indies) .... *ludens* Loew.

I hesitate in offering the above table, for I realize its deficiencies. I have not seen all the species mentioned and had to to depend on the descriptions; therefore, it should be used as a guide for the study of the genus rather than an implement for the accurate placing of the species.

Chrysopila lucifera, n. sp.

Male: Head black; frontal triangle, face and cheeks gray pollinose; antennæ and palpi black, the latter long, subclavate, thickly black pilose; proboscis with brownish cast; pile of cheeks black. Thorax black, pollen dark gray on mesonotum, light on pleuræ; mesonotum with golden yellow tomentum, sparse pile dark brown; scutellum black, golden yellow tomentose; halteres black. Abdomen black, tomentum of dorsum golden yellow; pile white. Coxæ black, with black pile; femora blackish, tibiæ and base of tarsi yellow. Wings subfuscous; stigma slightly elongate; bend of anterior branch of third vein rectangular, sometimes furnished with a stump.

Female: Same as male except pile of cheeks and coxæ is white, palpi shorter and not so thickly pilose; front brownish gray pollinose, pile black, tomentum golden yellow. Femora somewhat lighter, and extreme tip of tibiæ fuscous. Length, 6–7 mm.

Three males from Washington and one female from California.

Chrysopila bella, n. sp.

Male: Head black; occiput, frontal triangle, face and cheeks dusted with bluish gray pollen; pile sparse and white; antennæ dark brown, the third joint lighter than the other two; proboscis yellowish, palpi brown, pile white; ocellar tubercle prominent. Thorax black; mesonotum with grayish brown pollen, that of the humeri and lateral margins gray, tomentum golden yellow; pleuræ light gray pollinose, with light-colored pile above front coxæ and behind and below base of wings; scutellum grayish brown, covered with golden yellow tomentum; metanotum light gray pollinose; halteres yellow, knobs brownish black. Abdomen black; first segment light gray pollinose, remaining segments, in certain lights, grayish brown pollinose, in others, opaque black, and in others still the segments appear to be the former color on the apex and the latter on the base; pile white, tomentum golden yellow. Coxæ blackish, apex with a yellowish cast; pollen light gray; femora and tibiæ light yellow; tarsi yellowish at base, black at apex. Wings hyaline, anterior branch of third vein without stump.

Female: Same as male except the antennæ and palpi are darker, the abdomen is uniformly gray pollinose; knobs of halteres yellow, trochanters are blackish, and bend of anterior branch of the third vein is rectangular and with a stump. Length, 5.75–6 mm.

Two male specimens from California and one female from Washington.

Chrysopila flavibarbis, n. sp.

Male and female: Head black, grayish pollinose, front of female brownish pollinose; pile of occiput, sides of face and of palpi yellow; antennæ black. Thorax black, gray pollinose; mesonotum, except front, lateral and hind margins in female velvety black; sparsely covered with yellow tomentum, and on sides having yellow pile; pleuræ bare; scutellum of a brownish

cast and with yellow pile; knobs of halteres blackish, base yellowish. Abdomen black, grayish brown pollinose, sparsely covered with yellow tomentum and pile. Coxæ black, yellowish pollinose, femora except tips piceous, with sparse tomentum, extreme tip of femora, tibiæ and basal half of metatarsi yellowish, remainder of tarsi fuscous. Wings subfuscous, stigma brown. Length, 5 mm.

Seven specimens; Colorado and Wyoming. The ones from Colorado were received from C. W. Johnson, to whom they are returned.

Symphoromyia flavipalpis, n. sp.

Female: General color ash gray; pile of front and vertex black, of occiput, cheeks and palpi white; first joint of antennæ moderately enlarged, brownish yellow, with short black hairs; second joint small, darker, third joint yellow, one and a half times as broad as the first joint, arista black; palpi and sides of epistoma yellow. Mesonotum with three indistinct brownish stripes, the central one abbreviated behind and divided longitudinally by a brownish yellow line, lateral or subdorsal stripes abbreviated in front, and divided at the suture; pile mixed white and black; pleuræ nearly bare, pile of scutellum black, halteres yellow. Abdomen brownish gray pollinose, pile white. Coxæ black, pile white, femora except extreme tip of a brownish cast; tip of femora, tibiæ and basal half of metatarsi yellowish; remainder of tarsi fuscous. Wings hyaline, veins dark brown, stigma yellow. Length, 6 mm.; wings, 6.25 mm.

Very close to *S. cinerea* Johns. On examination of two type specimens of *cinerea*, I noticed the palpi of the male to be black, and of the female to be black on the apical half. I wrote to Professor Johnson to examine the remaining type specimens, and he informs me that the tip of the palpi of these also are tinged with black. The third joint of the antennæ is broader, and the abdomen is slightly different in color.

One specimen, from Wasatch mountains, received from C. W. Johnson; another one from Colorado.

LEPTIS.

TABLE TO THE SPECIES.

1. Black, blackish, or fuscous 2
   Flavous, ochraceous, or pale testaceous 12
2. Wings distinctly ornamented 3
   Wings hyaline, gray or grayish subfuscous 5
3. Antennæ and palpi black 4
   Antennæ only partly black, palpi brownish, 8 mm .... *mystacea* Macq.
4. Abdomen pale at base .... *punctipennis* Say.
   Abdomen not pale at base .... *plumbea* Say.
5. Abdomen at least with second, third and posterior margin of fourth segments in part testaceous 6
   Abdomen with only the posterior margins of the segments testaceous, *incisa* Loew.
   Abdomen wholly black; grayish pruinose .... *pruinosa* Bigot.
   Abdomen with first segment blackish at base, second and third segments with a large sinuous black band at base, following segments black, bordered with brown .... *hoodiana* Bigot.
   Second and third segments with a broad yellow band at base, the posterior margins of which are deeply emarginate (Mexico)... *bitæniata* Bell.
6. Palpi black pilose 7
   Palpi white or yellowish white pilose 8
7. Palpi black in ground color .... *dimidiata* Loew.
   Palpi yellow in ground color .... *palpalis*, n. sp.
8. Coxæ black 9
   Coxæ yellow, or obscurely brownish yellow 10
9. First abdominal segment wholly black .... *maculifera* Bigot.
   First abdominal segment largely yellow .... *albibarbis* Bigot.
10. Mesonotum in certain lights subshining .... *pleuralis*, n. sp.
    Mesonotum opaque 11
11. Second and third segments wholly yellow except a black spot at base (female) .... *albibarbis* Bigot.
    Second and third segments with only the posterior margin yellow (Mexico) .... *politæniata* Bell.
12. Wings spotted .... *albicornis* Say.
    Wings not spotted or luteous on costal or posterior margin 13
13. Abdomen with a dorsal series of black spots, with bases of segments fasciate black 14
    Abdomen without such spots or fasciæ 17
14. First antennal joint of the female, first two of male, black, 7.1–7.8 mm, *scapularis* Loew.
    Antennæ otherwise colored 15
15. Antennæ dilute luteous 16
    Terminal joints only, of each sex, pale .... *vertebrata* Say.

16. Posterior tarsi brownish black, 10.7–13.5 mm................*costata* Loew.
    First joint of hind tarsi brownish yellow, 7 mm...............*boscii* Macq.
    Entire tarsi dull ferruginous, 8–9 mm....................*intermedia* Walk.
17. Pile of abdomen long, black on dorsum, pale on sides...........*hirta* Loew.
    Pile not long, differently distributed................................ 18
18. First joint of the antennæ black ....*terminalis* Loew.
    First joint of antennæ yellow..............................*ochracea* Loew.

Some of the species in this table were given their position solely by reference to their descriptions; hence their true location might have been missed.

Leptis pleuralis, n. sp.

Female: Head black, grayish pollinose, pile yellowish white, antennæ brown, first joint yellowish, proboscis brownish yellow; mesonotum black, gray pollinose, viewed from behind subshining, except lateral margins and two subdorsal lines, short pile yellowish, longer ones more numerous and black; humeri and postalar callosities tinged with yellow; pleuræ variegated with brown and yellow, almost wholly devoid of pile; scutellum with a yellowish cast, brownish on top, halteres yellow; abdomen testaceous, a spot on the fourth segment, and fifth segment except narrow hind border, piceous, following segments opaque, pile mostly pale yellowish, a few black ones; coxæ and legs yellow, tip of tarsi brown, pile of coxæ whitish yellow, those of legs short, yellow and intermixed with black ones; wings hyaline, tinged with fuscous along anterior margin and base, stigma almost obsolete. Length, 7 mm.

One specimen; Washington. Close to *L. albibarbis* Bigot, but is smaller, thorax subshining, coxæ and legs less marked with fuscous.

Leptis albibarbis Bigot. Bull. Soc. Zool. de France, xii p. 18.

A male specimen from Seattle, Wash., agrees with the female except that the coxæ, femora largely, and scutellum are black; the abdomen is yellow, a small spot on first, third, fourth and fifth segments, and sixth and seventh, except sides, black. A female specimen from the same source has the anterior coxæ largely, and the two posterior pair at base, black, the front femora with an indistinct, subapical band, and the hind pair with the distal half brown.

Leptis palpalis, n. sp.

Male: Head black, occiput, frontal triangle, face and cheeks gray pollinose and white pilose; proboscis and palpi yellow, pile of latter black; antennæ dark fuscous, tip of second joint, and third wholly, yellowish, arista black. Thorax black; mesonotum brownish pollinose, marked with a hair-like line in the middle, two subdorsal broader ones, and lateral margins gray pollinose, pile black; humeri testaceous, scutellum likewise, with base and pile black; pluræ gray pollinose, pile above front coxæ, and on metapleuræ white; halteres yellow. First, second, third and fourth abdominal segments, except in middle and on sides, yellow; remaining segments, except narrow posterior margins, black; pile black. Coxæ black, with white and black pile, trochanters black, femora, except poorly defined brownish ring in middle of the two anterior pair, and apical half of hind pair, yellow; four front tibiæ yellow, hind ones and all tarsi fuscous. Wings hyaline, with a subfuscous tinge, most prominent on anterior half and along veins; stigma elongate. Length, 10.5 mm.

One specimen; Washington.

Chrysops pachycera Will.

Numerous specimens of each sex from the Bill Williams Fork, Arizona, compared with the types convince me that the male and female specimens Doctor Williston had before him are, as he then suspected, and as Townsend later believed, of different species. Furthermore, it has been pointed out to me (thanks to Prof. Jas. S. Hine) that the male of Doctor Williston's types is the male of *C. proclivis* O. S. Therefore the name *pachycera* must stand for the females of that description, to which I will add the following notes: The shining black intervals on the mesonotum are, in perfect specimens, covered with pollen which causes an apparent darker ground color on these parts. The pollen on these stripes is very easily dislodged, however, and in a large series of specimens one will find a goodly number presenting these vittæ shining. The pollen of the scutellum is also easily rubbed off and leaves a shining ground color. The color of the female abdomen is variable. In some specimens the dark markings are very indistinct, especially on the first and second segments. In others

the general color is similar to that of the thorax, being darker only on the black markings. The male head agrees with that of the female. The mesonotum, except on sides which are whitish pollinose, is darker and with longer pile. The pleuræ are generally largely yellowish pollinose, but often with only a longitudinal stripe above base of coxæ. The coloration of the abdomen is not so variable as in the female, being yellow, with a prominent median double row of black spots, which are often broadly coalesced on the first, second and third segments, but do not reach the posterior margin. On the third, fourth, fifth and sixth segments are two lateral rows of black spots not attaining the posterior margin. Often all the spots on the last segment coalesce and the segment is black, except the very narrow lateral and posterior borders, and often the pollen is dislodged leaving the segment shining black. The wing agrees with the female wing, except the two basal cells are infuscated on their basal two-thirds. Halteres in each sex yellow.

Psilocephala occipitalis, n. sp.

Male: Occiput black, yellowish in the middle beneath, white pollinose, bristles small and yellowish, vertex yellowish pollinose, front white pollinose, except upper angles, which are yellowish, face white pollinose, antennæ yellow, first joint about twice the length of the second, third slightly longer than the first, its extreme tip and arista black, mouth-parts yellow, sparsely yellow pilose, cheeks yellow pollinose. Thorax yellow, mesnotum and dorsum of scutellum with a coating of yellow pollen, the very small yellow pile few in number, bristles yellow, four in number on the scutellum, pleuræ, under side of scutellum, and metanotum with a coating of white pollen, halteres yellow. Abdomen yellow, under side of first segment, apices of second and third white pollinose, sparse yellow pile scarcely perceptible, venter with first segment, apices of second, third and fourth narrowly white pollinose; legs and their pile yellow, bristles brownish yellow, coxæ white pollinose. Wings hyaline, with a faint fuscous tinge, fourth posterior cell open. Length, 7.9 mm.

One specimen; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

Psilocephala lateralis, n. sp.

Male: Head black, front shining, except the lower corners, which are white pollinose, face white pollinose, antennæ black, third joint with a faint reddish cast at base, first and second with black bristles, first and third subequal in length, third broader at middle than at ends, arista small and acute, mouth-parts black, pile of palpi white, at junction of face and cheeks is a deep black spot, bearing short black pile, cheeks and occiput white pollinose, the former with abundant white pile, bristles of latter black. Thorax black, dorsum of mesonotum and scutellum grayish brown pollinose, except broadly on sides, which are shining, pile yellowish white, bristles black, the latter four in number on the scutellum, pleuræ white pollinose and pilose, halteres lemon yellow. Abdomen black, shining, the first segment abundantly white pollinose, and pilose, likewise the apices of the second and third segments, viewed from in front, the dorsum of all segments solid sericeous, which is scarcely visible from rear view, venter with the first and tip of second and third segments white pollinose, all segments sparsely white pilose, tip of hypopygium with a yellowish cast. Legs black, pile white, bristles black, coxæ white pollinose, middle and hind tibiæ and tarsi reddish yellow. Wings with a yellowish brown tinge, darkest on the anterior half, the fourth posterior cell closed and short petiolate. Length, 7 mm.

One specimen; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

Thereva anomala, n. sp.

Male: Head and members black, front shining, in certain lights a sprinkling of white pollen can be detected along sides, face, cheeks, and occiput white pollinose, pile of vertex, front, face and mouth-parts black, of cheeks and occiput white, bristles of latter and of first joint of antennæ black, first and third joint of antennæ subequal in length, either about four times as long as the second. Thorax black, mesonotum gray pollinose, except broadly on sides which are shining, and with a mid-dorsal line velvety black, pile and bristles black, scutellum gray pollinose, with four black bristles and rather numerous black pile, plueræ with a thin coating of white pollen, pile white, a rather prominent tuft of white pile before base of halteres, lat-

ter black. Abdomen black, pile white, dorsum of second and following segments, when viewed from before, solid sericeous, scarcely perceptible from behind, hind border of second segment white pollinose, venter shining, except the narrow hind border of the second segment, pile white, tip of hypopygium yellowish. Coxæ and legs black, pile white, bristles black, front tibiæ anteriorly, middle and hind tibiæ posteriorly, yellow, and with coating of white pollen, base of middle and hind tarsi yellowish. Wings hyaline, with two brown cross-bands, one from stigma to apex of fourth posterior cell, the second from apex of second vein across submarginal cells to apex of first posterior cell.

The female resembles the male except the pile of front and face is not so thick, and the abdomen is not sericeous. Length, male, 9 mm., and female, 10.2 mm.

A specimen of each sex from Oak Creek canyon, Arizona. Collected by Dr. F. H. Snow. This species resembles certain forms of *Psilocephala*, but the pilosity of the face leaves no doubt of the generic position.

Scenopinus mirabilis, n. sp.

Female: Black, head and thorax subopaque, abdomen shining, with short white pile; first antennal joint slightly shorter than the second, closely applied to it, their separation difficult to see; third joint twice as long as the first two together, tapering somewhat from the middle apically; a small spot on humeri, and halteres yellow, abdomen broad and long, once and a half times as long as the wings, twice as long as the head and thorax together, knees and tarsi, except tips of latter, yellow; wings hyaline, veins dark brown, width of first posterior cell at margin of wing is scarcely equal to the length of the small cross-vein. Length, 4 mm.

One specimen; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow. Were it not for the open first posterior cell and short submarginal cell, this species would well be located in *Pseudotrichia*.

Scenopinus electa, n. sp.

Male: Black, with very short white pile; head and thorax subopaque, abdomen shining, hind margins of segments three, four and five white; lower half of eyes of smaller facets than

upper half; first and second joints of antennæ of equal length, third two and a half times as long as both together, in certain lights third is of a brownish color, palpi linear, yellow at tip, knob of halteres pure white, knees and basal half of tarsi yellowish, all tibiæ in certain lights brownish; wings hyaline, veins brown, width of apex of first posterior cell but little less than the length of the small cross-vein.

Female: Agrees with the male, except the palpi are very much enlarged at apex, clavate, tip brownish yellow, and none of the abdominal segments have white posterior borders. Length, 2.5 mm.

A specimen of each sex; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

Nausigaster scutellaris, n. sp.

Male: Black, whitish pollinose and punctulate as in *N. punctulata* Will., short pile of whole body white; occiput, vertex, front, face except tip of tubercle, white pollinose, the lower half of the face reddish brown, mouth-parts retracted, brownish, antennæ yellow, base of arista brownish yellow. Dorsum of thorax with five subshining, bare, longitudinal vittæ, which in certain lights are bronze, the central one is straight, the two lateral ones converge and join posteriorly; pleuræ uniformly pollinose and punctulate; scutellum subshining, red, except extreme lateral angles and minute tubercles on posterior margin, which are black; halteres yellowish white. Venter and apex of abdomen with a reddish cast, dorsum with five broad, indistinctly defined, subshining vittæ, which in certain lights are bronze, the small concave space on base of second segment whitish pollinose, the pollen on either side of the median vittæ arranged in crescentric spots, with the concavity toward the median line, the fourth segment possessing two pairs of such spots. Legs black, extreme apex of femora, tibiæ and tarsi yellowish, a subapical band on hind tibiæ, and hind metatarsi brown, claws black. Wings hyaline, with a very minute brown spot at apex of auxiliary vein, spurious vein scarcely perceptible beyond the small cross-vein, first posterior cell closed a very short distance from the wing margin, last section of fourth vein without stump on anterior side,

but a very short one at angle on posterior side, the fifth vein is continued as a short stump beyond the posterior cross-vein. Length, 6 mm.

Two specimens; Congress Junction, Ariz. Collected by Dr. F. H. Snow.

Nausigaster geminata Towns.

A female specimen from Oak Creek canyon, Arizona, agrees with Townsend's description, except the spurious vein is narrowly bordered with brown, there is a small spot on apex of third vein, the third vein emits a stump on posterior side a little before the middle of the first posterior cell, the last section of the fourth vein has a stump on posterior side at first angle and one on anterior side at second angle, fifth vein is continued as a stump beyond the hind cross-vein.

Nausigaster punctulata Will.

A male specimen from Oak Creek canyon, Arizona, agrees with the description of this species, except the last section of the fourth vein emits a stump near its middle on the anterior side, the fifth vein is slightly infuscated just beyond the posterior basal cross-vein.

Sphyximorpha snowi, n. sp.

Female: Head yellow, the front from just above the ocelli to about half-way to antennæ, a broad stripe on cheeks, a narrow line from base of antennal process to mouth, and antennal process light reddish yellow; antennæ fuscous, the third joint, except on inner sides at base, black; mouth-parts fuscous; occiput at the middle on the sides blackish, covered with whitish pollen; pile of occiput and vertex white. Thorax red; humeri, a spot on outer end of suture, a superalar stripe, a large spot on mesopleuræ extending onto the sternopleuræ, and pteropleuræ, scutellum and halteres yellow. Abdomen reddish, very little constricted at base, the first segment with a large yellow triangle on each anterior angle which reaches to the posterior border, the subtriangular space on dorsum is largely black; the three following segments with a broad posterior yellow border, the last one of the three being a little over one-half the length of the segment in width. Legs reddish yellow, base of

all tibiæ a shade lighter. Wings hyaline, fuscous on anterior part, which color follows the spurious vein almost to the cross-vein, thence it borders the third vein posteriorly to the tip, a subhyaline space in each of the marginal and submarginal cells, the third vein bent deeply into the first posterior cell, and at this point bearing a stump posteriorly. Length, 12 mm.

Two specimens; Bill Williams Fork, Arizona. Dedicated to Dr. F. H. Snow, whose untiring energy results in so many good things.

Conops gracilis Will.

Specimens from Bill Williams Fork, Arizona, agree with this species, except the cheeks are generally blackish or red in color. This color varies in extent and is often resolved into numerous small dots. The attenuated portion of the antennal style is longer than in the type. The female differs from the male only in size, being larger, and the abdomen is more extensively pollinose.

Tetanocera inopa, n. sp.

Male: Head yellowish, occiput grayish pollinose, with a black spot in center, above which, in certain lights, shows a short whitish pruinose stripe on each side; front opaque, viewed from behind shows a very narrow silvery stripe along the eyes, a median longitudinal shining stripe passing over the black ocellar tubercle, is excavated in front of it, and attains the anterior margin, where it is tinged with brown, a black spot on each side of the antennæ, two more back of these, bearing the two lowest orbital bristles; antennæ testaceous, second joint shining, with bristly hairs above and below, slightly infuscated on upper side, third joint opaque, about equal to second in length, slightly excavated above, arista yellow and with white plumosity; face and cheeks immaculate, yellow, in certain lights whitish, mouth-parts yellow. Thorax testaceous; mesnotum grayish pollinose, bearing two subdorsal and two sublateral brown stripes; scutellum fuscous in center above, grayish pollinose on sides, with four bristles; pleuræ subshining; halteres yellow, knobs slightly infuscated. Abdomen brownish yellow, dark brown on dorsum, posterior borders of segments lighter, hypopygium sordid yellow. Legs yellow, last three

joints of fore tarsi and last two of both intermediate and hind tarsi blackish. The interrupted brown border of the wings does not reach the third longitudinal vein, the remainder of the wing very indistinctly reticulated, the hyaline spots arrange themselves on each side of the veins and leaves a very narrow brown band in the center of the interval. Length, 4.5 mm.

One specimen; Washington.

ICTERICA.

TABLE TO THE SPECIES.

1. The brown border at apex of wing contains a hyaline streak following the margin from just beyond the tip of second vein to just before tip of fourth vein.. *fasciata*, n. sp.
   The brown border not interrupted at this point........... 2
2. Two large brown spots completely surrounding the cross-veins, *lichtensteinii* Wied.
   Brown near cross-veins dissolved into smaller reticulations 3
3. The recticulations in the center of wing consist of small angular spots, arranged in double rows between the veins................ *scriata* Loew.
   The reticulations consist of small brown ringlets, either open or closed, *circinata* Loew.

Icterica fasciata, n. sp.

Male and female: Head and members yellow, arista, except extreme base, and bristles of front brownish. Thorax yellow, covered with yellow pollen and pile, bristles of mesonotum and scutellum yellowish brown, the latter four in number, halteres yellow. Abdomen yellow, shining, with yellow pile and pollen, ovipositor shining, its tip black. Legs, their bristles and pile, yellow. Wings brownish yellow reticulated, the reticulations, as in *I. circinata* Loew, consist of brownish ringlets, some open and some closed, but near the center of the wing the ringlets are of bolder face and of a darker shade of brown, causing a distinct band, arising at stigma and passing over both cross-veins to posterior border of wing, it is slightly concave, the concavity toward the base of wing, the costal border before stigma is yellow except for two indistinct brownish spots, and then for two-thirds the distance to tip of second vein is yellow, except for one small spot, the last third of this distance, or just before second vein, is brown save for two, sometimes three, small yellow spots, the first of which attains the costa, from tip of second vein there is a continuous brown band bordering

the wing around to the third posterior cell, and containing a small yellow dot just after tip of second vein, a narrow hyaline streak along apex of wing, three hyaline spots on border of wing in second posterior cell, and three in third posterior cell, from here to anal angle the wing border consists of an alternation of indistinct brown and hyaline spots; otherwise the wing resembles very much that of *I. circinata* Loew. Length, 4.5 mm.

Numerous specimens; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

URELLIA.

TABLE TO THE SPECIES.

1. Scutellum with two bristles.. 2
   Scutellum with four bristles.. 11
2. Basal half of wing with faded, but regular, reticulations, which consist principally of short, parallel streaks crossing the cells........*flava*, n. sp.
   Basal half not so marked.. 3
3. The rays on anterior side of large wing spot fused.........*conjuncta*, n. sp.
   These rays not fused.. 4
4. The Y-shaped mark at apex of wing absent or imperfect.................. 5
   The Y-shaped mark present.. 7
5. The anterior branch of the Y-shaped mark present........*nigricornis* Coq.
   The anterior branch absent or represented by a dot.................. 6
6. Middle femora without bristles..........................*imperfecta* Coq.
   Middle femora with four or five bristles below............*femoralis* Thom.
   radifera Coq.
7. Small cross-vein surrounded by the brown color.......................... 8
   Small cross-vein partly or wholly surrounded by hyaline................ 10
8. Fifth vein with a grayish brown spot or streak.......................... 9
   Fifth vein without any marking..........................*bisetosa* Coq.
9. Two rays in apex of discal cell..........................*occidentalis*, n. sp.
   Only one ray in apex of discal cell..........................*vicina* Wulp.
10. Fifth ray with a small dot near center of discal cell.......*actinobola* Loew.
    Fifth ray without such dot..........................*mevarna* Walk.
11. Basal half of wing with regular reticulations of short parallel streaks across the cells..........................*abstersa* Loew.
    Basal half not so marked.. 12
12. Apex of discal cell with one ray..........................*eugenia* Wulp.
    Apex of discal cell with more than one ray.......................... 13
13. Third posterior cell wholly hyaline..........................*polyclona* Loew
    Third posterior cell with markings.......................... 14
14. Third vein with bristles..........................*aldrichii* Doane.
    Third vein without bristles.......................... 15
15. Third posterior cell with three rays..........................*pacifica* Doane.
    Third posterior cell with two rays..........................*stigmatica* Coq.

Of some of the synonymy given by Mr. Coquillett in this group I am not prepared to approve or disapprove. Some of the species removed by him from this genus, however, I believe belong more properly to it than to any other.

Urellia flava, n. sp.

Female: Body wholly covered with yellow pollen; head and members yellow, arista and frontal bristles black, those of the occiput yellow. Thorax yellow, the mesonotum appears through the pollen to be black in ground color, metanotum likewise black, short pile yellow, bristles of mesonotum and scutellum black, latter two in number, halteres yellow. Abdomen yellow, the last two segments appear through the pollen to be blackish, ovipositor subshining yellow, tip black, pile yellow. Legs wholly yellow, with yellow bristles and pile. Wings very much like those of *U. abstersa* Loew, but the reticulations on proximal half are yellowish and become uniformly fused along the first ray from the subapical spot, the anterior branch of the Y-shaped mark at tip of wing is not connected with the ray preceding it, between the Y-shaped mark and the third vein is a deep black spot which on transmitted light is opaque and stands out from the surrounding less dark color, the same color exists in the tip of the small ray ending at the apex of the second vein, also in the apex of the short but broader ray preceding; otherwise the wing is as in *U. abstersa* Loew. Length, 3 mm.

One specimen; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow.

Urellia conjuncta, n. sp.

Female: Head and members yellow, arista and frontal bristles brownish black, those of the occiput yellow. Thorax black, gray pollinose, humeri, a spot before base of wing, pile and halteres yellow, bristles of mesonotum and scutellum black, the latter two in number. Abdomen black, gray pollinose, subshining, pile yellow, ovipositor shining black, with a few yellow pile at base. Legs yellow. The large spot on the wing has all the rays in front of the fourth vein fused, emitting only five rays on posterior side of this vein, the spot reaches along the costa to a point half-way between a point opposite the small cross-vein and tip of first vein, at which place it possesses a small hyaline dot, in base of first posterior cell is a hyaline spot

nearly as long as the width of the cell, another smaller one nearly over the hind cross-vein, besides the two subparallel rays in second posterior cell the large spot projects beyond the fourth vein, forming an irregular border to it, the hind cross-vein possesses one of the rays and the discal cell has two short rays near the apex, one arising under the small cross-vein and the other midway between the two cross-veins, there is a small dot on fifth vein near middle of discal cell, beginning at the small cross-vein and running to the stigma is a subfuscous tinge which proceeds proximad, filling the base of the marginal and submarginal cells, both basal cells, and the basal half of the discal cell. Length, 3.8 mm.

One specimen; Bill Williams Fork, Arizona. Collected by Dr. F. H. Snow. This species may require a new genus, yet I consider it nothing but an *Urellia* with all the anterior rays of the wing spot fused.

Urellia occidentalis, n. sp.

Male and female: Head and members yellow, upper part of front and occiput brownish, arista and frontal bristles black, those of the occiput yellow. Thorax black, gray pollinose, short pile, humeri, and spot before base of wings yellow, bristles of mesonotum and scutellum black, the latter two in number, halteres yellow. Abdomen black, gray pollinose, pile yellow, ovipositor shining, a few pile at base. Legs reddish yellow, pile and bristles yellow. Wings hyaline, the first ray of the subapical spot passes to stigma and is about as wide as the first posterior cell, its base surrounds the small cross-vein, on each side of which, near the fourth vein, is sometimes a very small hyaline dot, second ray arises half-way between the second and third veins, opposite the posterior cross-vein, and ends in costa opposite the mid-point between the two cross-veins, a hyaline spot at apex of second vein, no ray before the Y-shaped mark, base of latter one-third as wide as the first posterior cell, on under side of subapical spot are five subparallel rays, the middle, or third one, is on the hind cross-vein, the last two cross the discal cell to the fifth vein, then the last one borders the fifth vein to the base of discal cell, in the first

posterior cell, and nearly above the hind cross-vein, is a rather large hyaline spot. Length, male, 3.5 mm., and female, 4 mm.

Six specimens; Palo Alto, Cal., and Lance creek, Wyoming.

Elachiptera bilineata, n. sp.

Female: Head yellow; frontal triangle, occiput, except on the lower part, tip of third antennal joint, and arista black; pile yellow. Thorax shining black, pile yellow; mesonotum sparsely punctured, two subdorsal rows of grayish yellow, microscopic hairs, the rows widen caudad and almost meet in front of the scutellum; scutellum black, coarsely punctured, apical tubercles small; halteres light yellow. Abdomen shining black, pile yellow. Coxæ and legs yellow, anterior tibiæ and all tarsi brownish. Wings hyaline, veins at base of wing yellowish, on remaining part brownish, third and fourth veins beyond discal cell parallel, hind cross-vein more than its length from the small cross-vein. Length, 2.7 mm.

One specimen; Oak Creek canyon, Arizona. Collected by Dr. F. H. Snow.

Hippelates splendens, n. sp.

Female: Head black; narrow anterior border of front, face, antennæ except apex, and palpi yellow; frontal triangle shining. Thorax shining black; mesonotum and scutellum sparsely punctured, each puncture bearing a short whitish hair, scutellum also with an apical pair of bristles; halteres yellow. Abdomen black; venter yellowish basally, pile yellowish. Coxæ black, femora except apex, concolorous, tibiæ and tarsi yellow. Wings hyaline, veins yellowish brown. Length, 2.2 mm.

One specimen; Lusk, Wyo. Collected by Hugo Kahl.

LIMOSINA.

TABLE TO THE SPECIES.

1. Third section of costal vein longer than the second 2
   Third section of the costal vein shorter or equal to the second 6
2. Distal section of second vein longer than the first section of the third... 3
   Distal section of second vein not longer than the first section of the third .... *lugubris* Will.
3. Last section of third vein with a decided curvature forward, ending a considerable distance before apex of wing .... *perparva* Will.
   Third vein without such curvature, ending near apex of wing 4
4. Wings wholly hyaline .... *exigua*, n. sp.
   Wings at least somewhat infuscated on anterior portion 5
5. Front shining .... *occidentalis*, n. sp.
   Front largely opaque .... *sordipes*, n. sp.
6. Scutellum deep opaque black, noticeably different from the mesonotum, *scutellaris* Will.
   Scutellum not noticeablly different from the mesonotum 7
7. Third vein nearly straight, ending at tip of wing 8
   Third vein curving forward, ending before apex of wing 9
8. Scutellum shining .... *æqualis* Grimshaw.
   Scutellum opaque .... *pumila* Will.
9. Scutellum with reddish margin .... *dolorosa* Will.
   Scutellum not so marked 10
10. Front marked with red 11
    Front not marked with red 12
11. Front also with small silvery spots .... *venalicia* O. S.
    Front without such spots .... *illota* Will.
12. Entirely black .... *atra* Adams.
    Not entirely black 13
13. Cheeks and mouth-parts largely yellow .... *setigera* Adams.
    Cheeks and mouth-parts black 14
14. Scutellum with eight bristles .... *fontinalis* Fall.
    Scutellum with six bristles .... *aldrichi* Will.

Limosina exigua, n. sp.

Male and female: Front opaque black, with median line shining, occiput black, shining, face, cheeks and mouth-parts dull light colored; antennæ black, arista pubescent. Thorax black, shining, pleuræ with a brownish cast, halteres white. Abdomen black, shining, venter brownish. Wings hyaline, third section of costa longer than second, first section with a few long bristly hairs, last section of second vein longer than the first section of the third, joining the costa nearly opposite

the apex of discal cell, distal portion of third vein nearly straight, ending slightly before apex of wing. Length, .8–.9 mm.

Numerous specimens; Las Cruces, N. M.

Limosina occidentalis, n. sp.

Male: Head shining, vertex and lower part of face black, remainder with a brownish cast, antennæ dark brown, second joint with a coronet of strong bristles, arista pubescent. Thorax shining dark brown, pleuræ obscurely marked with yellow, halteres whitish. Abdomen brownish black, apex black, shining. Coxæ and legs brownish yellow, shining, tarsi yellow. Wings hyaline, anterior portion, except a triangular space beyond apex of second longitudinal vein, and narrowly along fifth vein, infuscated, third section of costa longer than second, distal section of second vein longer than first section of third, joining costa slightly beyond the apex of discal cell, third vein straight, ending near apex of wing. Length, 1.75 mm.

One specimen; Palo Alto, Cal. Collected by R. W. Doane.

Limosina sordipes, n. sp.

Male and female: Front opaque black, occiput, vertex, face and cheeks shining black, mouth-parts and antennæ black, arista pubescent. Thorax black, mesonotum and scutellum subopaque black, pleuræ obscurely marked with yellow, knobs of halteres brownish. Abdomen shining brownish black, posterior margins narrowly light brown. Coxæ and legs brownish, tarsi yellowish. Wings hyaline, subfuscous on anterior portion, most marked on second and third longitudinal veins, third section of costa longer than second, distal section of second vein longer than the first section of third vein, joining costa slightly beyond apex of discal cell, third vein nearly straight, ending slightly before apex of wing. Length, 1–1.4 mm.

Numerous specimens; Brookings, S. Dak.

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CONTENTS:

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COAL MEASURE FAUNAL STUDIES, III.

LOWER COAL MEASURES.

BY J. W. BEEDE AND AUSTIN F. ROGERS.[1]

THE authors are aware that the term "Coal Measures" is becoming obsolete, but, for the sake of uniformity, the title will be continued in this and the succeeding papers. This also is true of certain fossils given in the lists, such as the *Pleurotomarias* and the *Bellerophons*. In the final paper the terminology of the fossils will be carefully brought up to date.

In collecting the material from the Lower Coal Measures the authors, working together, endeavored to collect quantitively the fossils found in the various horizons. The fact that one was interested in the Bryozoa and the smaller crustacea, while the other was more familiar with the other forms, has, we hope, tended to make the results more complete. Aside from this, every effort was made to eliminate the personal equation so far as possible. Particular care was taken not to overlook the commoner forms in order to secure the more rare ones. The latter were, however, industriously sought, but every specimen seen was noted and, whenever possible, was taken. However, these lists are not to be looked upon as complete, for the faunas of each horizon will be very materially increased by prolonged and careful collecting. Our collections are sufficiently complete, we believe, to show most of the salient features of the faunas as units. The remaining additions will consist largely of extending the known range of the forms in associated rocks and the discovery of rare and unique species.

In the following lists the usual conventional characters in-

1. The work of the authors in this paper was coordinate and the seniority of authors is without significance.

dicating the relative abundance of specimens are employed,[2] but in the final paper an entirely different and more definite scheme will be followed.

The discussion of the range and distribution of species and other important subjects will be given in the final paper, which will probably follow two other papers on the fauna of the Coal Measures.

Doctor Girty[3] has published lists of fossils assigned to the rocks here under consideration, but no localities from which they were taken are given. For convenience in comparing our lists with his, the species common to both lists will be followed by an asterisk in our list, and those not represented in our list will be given as foot-notes to the list of each horizon. *In no case are his species to be considered as incorporated in our lists.*

For a synopsis of the literature on the Lower Coal Measures the reader is referred to Adams's recent paper,[4] which gives a review of the literature and synonomy of the formations.

The rocks here included under the term "Lower Coal Measures" are the following:

Dudley (Upper Pleasanton) shales.
Altamont (Parsons)[5] limestone.
Bandera (Lower Pleasanton) shales.
Pawnee limestone.
Labette shales.
Fort Scott (Oswego) limestone (Lower, Shales, and Upper).
Cherokee shales.

CHEROKEE SHALES.

The Cherokee shales are from 400 to 500 feet in thickness, heavily coal-bearing, and, on the whole, rather arenaceous, though their texture varies from jet black carbonaceous shales through sandstone to limestone at various places and horizons. Fossils are, as a rule, very rare. We were able to discover few save in the calcareous layers of small extent. These were found at Cherokee, Oswego, and Frontenac. In these layers fossils are abundant. These horizons are all in the upper part of the shales, no fossils having been found in the lower part.

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2. aa = very abundant; a = abundant; c = common. The remainder are indicated by x.

3. Bull. 211, U. S. Geol. Surv., pp. 29-34, 1903.

4. Bull. 211, U. S. Geol. Surv., 1903.

5. The term "Altamont" seems to have been changed arbitrarily to "Parsons," which should not be used.

The localities from which our fossils were taken are the following, which are briefly indicated in the list: (*a*) Coal-shaft one mile southwest of Cherokee, Kan. The fossils are from a calcareous and pyritiferous layer some distance above the coal. (*b*) A limestone lens one-half mile west of Cherokee, northwest of the county high school building and east of the old smelter, on the south (east) bank of the little creek. It is probably four or five feet in thickness, though very poorly exposed. (*c*) North Leavenworth and Riverside coal-shafts, at Leavenworth, Kan., and the Carr coal-shaft at Richardson. The coal mined in these shafts is in the Cherokee shales. (*d*) Coal-shaft one and one-half miles northeast of Frontenac, Kan. The fossils occur in a buff earthy limestone above the coal. (*e*) Strip-pit coal-mine one and one-half miles southeast of Oswego, Kan. Doctor Newlon informed Doctor Rogers when there that this pit was the locality and horizon from which the type specimens of the cephalopods described by Hyatt and listed below were taken. Doctor Newlon collected the cephalopods referred to.

	Cherokee shaft. a.	Cherokee limestone. b.	Leavenworth. c.	Frontenac. d.	Oswego. e.
Axophyllum sp	x				
Axophyllum rude White and St. John,		x			
Chætetes milleporaceous Edwards and Haime		x			
Lophophyllum profundum (Edwards and Haime)*			x		x
Lophophyllum sp				x	
Fistulipora nodulifera Meek		x			
Prismopora triangulata White		x			
Rhombopora sp	x	x			
Ambocœlia planoconvexa (Shumard)	x	x			x
Chonetes granulifer Owen	x		x		
Chonetes flemmingi Norwood and Pratten*		x			
Chonetes mesolonus Norwood and Pratten*	x	c	x	x	c
Chonetes sp	x			x	
Cleiothyris roissyi L'Eveillé	x	x			
Crania modesta White and St. John				x	x
Derbya bennetti Hall		x			
Derbya crassa (Meek and Hayden)			x	x	
Derbya? sp		x			
Hustedia mormoni (Marcou)		x			
Lingula umbonata Cox			x		

	Cherokee shaft. a.	Cherokee limestone. b.	Leavenworth. c.	Frontenac. d.	Oswego. e.
Orbiculoidea missouriensis (Shumard),	x	......	c	......	c
Productus cora d'Orbigny............	x	x	......	x	x
Productus longispinus (Sowerby)......	......	c	......	......	......
Productus muricatus Norwood and Pratten*........................	a	c	a	aa	a
Productus nebrascensis Owen*........	x	......	......	......	......
Productus semireticulatus (Martin)....	x	x	x	x	......
Pugnax utah (Marcou)...............	......	......	x	x	x
Reticularia perplexa (McChesney).....	x	a	......	......	.....
Seminula argentia (Shepard)*	c	c	x	......	.....
Spirifer cameratus Morton*...........	x	x	x	x	.....
Spiriferina kentuckiensis (Shumard)..	......	......	x	......	.....
Allorisma costatum Meek and Worthen,	......	x	......	.....	.....
Allorisma subcuneatum Meek and Hayden	......	x	......	x	.....
Astártella ? sp	......	......	......	......	x
Astartella varica McChesney?.........	......	......	......	......	x
Aviculopecten interlineatus Meek and Worthen	......	x	......	x	.....
Aviculopecten occidentalis (Shumard)?	x	......	......	......	.....
Aviculopecten rectilaterarius Cox......	......	......	x	......	.....
Aviculopecten sp	......	x	......	......	.....
Aviculopecten sp	......	......	x	......	.....
Entolium aviculatum (Swallow)??.....	......	x	......	......	.....
Macrodon ? sp	......	......	x	......	.....
Macrodon tenuistriatus Meek and Worthen ?.........................	x	......	......	......	.....
Myalina sp.........................	......	......	......	x	.....
Nucula ? sp.........................	x	......	......	......	.....
Nucula ventricosa Hall...............	......	......	x	......	.....
Nuculana bellistriata attenuata Meek,	......	......	x	......	.....
Pelecypod sp	.....	......	......	x	.....
Pelecypod sp........................	......	......	......	x	.....
Schizodus sp.........................	x	x	......	......	.....
Yoldia knoxensis McChesney..........	......	......	x	......	.....
Aclisina minuta (Stevens).............	c	....	......	......	.....
Bellerophon carbonaria Cox ?..........	......	......	......	......	x
Bellerophon montfortianum Norwood and Pratten	......	......	......	......	x
Bulimorpha inornata (Meek and Worthen).........................	......	......	......	x	....
Bulimorpha sp.......................	x	......	......	......	....
Dentalium sp........................	......	......	x	......	....
Gastropod sp........................	......	x	......	......	....
Gastropod sp........................	x	......	......	......	.....
Loxonema sp........................	x	......	......	......	.....
Loxonema sp........................	x	......	......	......	.....
Pleurotomaria brazoënsis Shumard....	x	......	......	......	....

	a. Cherokee shaft.	b. Cherokee limestone.	c. Leavenworth.	d. Frontenac.	e. Oswego.
Pleurotomaria scitula Meek and Worthen?	......	......	......	......	x
Pluerotomaria sp.	......	..	x	......	......
Pleurotomaria cf. subsinuatum Meek and Worthen	x	......	......	......	......
Pleurotomaria sphærulata Conrad	x	......	......	......	x
Sphærodoma intercalaris (Meek and Worthen)	......	......	......	......	x
Sphærodoma sp.	x	......	......	......	......
Strophostylus nanus (Meek and Worthen)?	......	......	......	x	......
Asymtoceras newloni Hyatt	......	......	......	......	x
Cephalopod sp.	......	......	x	......	......
Domatoceras umbilicatus Hyatt	......	......	......	......	x
Orthoceras cribosum Geinitz	......	......	......	......	x
Orthoceras sp.	x	x	......	......	......
Temnocheilus crassus Hyatt	......	......	......	......	x
Temnocheilus depressus Hyatt	......	......	......	......	x
Temnocheilus latus Hyatt	......	......	......	......	x

Doctor Girty (op. cit., p. 29) also accredits *Lingula carbonaria* to this horizon.

FORT SCOTT LIMESTONE.

This term includes three strata, the Lower Fort Scott limestone, as hale bed about seven or eight feet thick, and the Upper Fort Scott limestone. Each of these three strata will be treated separately, beginning with the

Lower Fort Scott Limestone.—A massive, gray, argillaceous limestone about four and one-half feet thick, resting on the Cherokee shales. At Fort Scott it is locally known as the "cement rock," and is extensively used for hydraulic cement. Fossils are fairly well disseminated throughout the mass.

Localities: (*a*) Fort Scott, at the cement works north of the city, across the Marmaton river; in the city, at the cement works just south of the Frisco railroad station, and at quarries about the town. (*b*) At Oswego, Kan., in a railroad cut just east of the Frisco station. (*c*) McCune; railroad cut just east of town.

	a. Fort Scott.	b. Oswego.	c. McCune.
Fusulinella sp	c	c	x
Aulopora? anna Beede?*	x	x	.....
Campophyllum torquium Owen*	x	......	.....
Chætetes milleporaceous Edwards and Haime	x	a	.....
Lophophyllum profundum (Edwards and Haime)*	x	......	.....
Syringopora sp	x	x	.....
Archæocidaris sp	......	x	.....
Fenestella sp	......	x	.....
Fenestella wortheni Ulrich?	x	......	.....
Fistulipora nodulifera Meek	x	x	.....
Polypora elliptica Rogers	x	......	.....
Polypora submarginata Meek?	x	......	.....
Prismopora triangulata White*	c	c	.....
Rhombopora lepidodendroides Meek	c	......	.....
Rhombopora sp	x	......	.....
Septopora sp	x	......	.....
Stenopora carbonaria (Worthen)	x	....	.....
Streblotrypa prisca Gabb and Horn	x	......	.....
Ambocœlia planoconvexa (Shumard)	a	......	.....
Chonetes flemmingi Norwood and Pratten	c	......	.....
Chonetes mesolobus Norwood and Pratten*	c	......	.....
Chonetes sp	......	......	x
Chonetes verneuilianus Norwood and Pratten	x	......	.....
Derbya crassa (Meek and Hayden)	c	......	.....
Derbya keokuk Hall?	x	......	.....
Hustedia mormoni (Marcou)	......	x	.....
Meekella striaticostata (McChesney)*	c	......	.....
Productus cora d'Orbigny*	x	x	.....
Productus costatus (Sowerby)?	x	......	.....
Productus longispinus (Sowerby)	a	a	.....
Productus muricatus Norwood and Pratten	a	......	.....
Productus pertenuis Meek	x	......	.....
Productus punctatus Martin*	a	a	.....
Productus semireticulatus (Martin)*	c	a	x
Pugnax utah (Marcou)	x	......	.....
Reticularia perplexa (McChesney)	x	x	.....
Seminula argentia (Shepard)*	c	c	x
Spirifer cameratus Morton*	c	c	.....
Spiriferina kentuckiensis (Shumard)	x	......	.....
Allorisma subcuneatum Meek and Hayden	c	......	.....
Aviculopecten carboniferus (Stevens)	......	x	.....
Aviculopecten providencesis Cox	x	......	.....
Aviculopecten sp	x	......	.....
Myalina subquadrata Shumard	x	......	.....
Pelecypod sp	x	......	.....
Schizodus harii Miller?	x	......	.....
Bellerophon bellus Keyes?	x	......	.....
Bellerophon crassus Meek and Worthen	x	......	.....

	a. Fort Scott.	b. Oswego.	c. McCune.
Bellerophon sp	x	......	......
Euomphalus sp. cf. subrugosus Meek and Worthen	x	......	.....
Gastropod sp	x	......	......
Pleurotomaria sp	x	......	......
Sphærodoma ? sp	x	......	......
Straparollus sp	x	......	......
Strophostylus nanus (Meek and Worthen)	x	......	......
Ephippoceras divisum White and St. John	......	x	......
Orthoceras sp	x	......	......
Phillipsia major Shumard	x	......	......
Griffithides scitula (Meek and Worthen)	x	x	......
Fish spine	x	......	......
Fish tooth	x	......	......

Girty also refers the following fossils to the horizon, without locality:

Fusulina cylindrica.
Sponge.
Rhipidomella pecosi.
Productus nebrascensis.
Allorisma terminale.
Edmondia sp.
Trepospira sphærulata.
Naticopsis altonensis.
Loxonemà ? sp.

Reference should be made here to Dr. John Bennett's list of fossils from the vicinity of Fort Scott, the fossils of which were collected during his residence there, and the list compiled, referring the species to their exact horizon, for the University Geological Survey.[6]

There are about twenty-eight such species in the list from the Lower Fort Scott limestone.[7]

Shales between the Fort Scott Limestones.—Seven or eight feet of bituminous shale. The extremely calcareous shales at the top were classed in with the limestone above, which accounts for the very few species given here under this head. The bitu-

6. Vol. I, 1896, pp. 286, 287.

7. In order to make the information of this paper as complete as possible, these species are quoted here, all from the vicinity of Fort Scott:

Axophyllum rudis.
Cyathaxonia distorta.
Chætetes carbonarius.
Athyris lamellosa.
Discina nitida.
Orthis (carbonaria) pecosi.
Productus americana.
Productus nebrascensis.
Edmondia aspenwallensis.
Nucula ventricosa.
Nuculana bellistriata.
Bellerophon carbonaria.
Bellerophon montfortianus.
Bellerophon percarinatus.
Naticopsis ventricosa.
Pleurotomaria broadheadi.
Pleurotomaria speciosa.
Pleurotomaria sphærulata.
Pleurotomaria turbiniformis.
Conularia crustula.
Goniatites sp.
Nautilus ferratus.
Nautilus occidentalis.
Orthoceras rushense.
Orthoceras sp.
Dithyrocaris sp.
Petrodus occidentalis.
Scales and dermal plates of fish.

In addition to these, there are several others in his list which may or may not be represented in our list.

minous shales, where we saw them, were nearly non-fossiliferous. The fossils mentioned below were taken from the railroad cut just east of the Frisco depot and at McCune:

Orbiculoidea missouriensis (Shumard)*, common at both localities.
Fish tooth? at Fort Scott.

Girty refers the following (all of which, except *Spirifer cameratus* Morton, are included in our list from the upper limestone) to this horizon:

Axophyllum rude.	Marginifera muricata.
Rhipidomella pecosi.	Spirifer cameratus.
Chonetes mesolobus.	Spiriferina kentuckiensis.
Chonetes flemmingi.	Cleiothyris orbiculatus.

Doctor Bennett gives the following:

Chonetes mesoloba.	Goniatites sp.
Spirifer planoconvexus.	Petrodus occidentalis.
Bellerophon percarinatus.	Scales and dermal plates of fish.
Pleurotomaria broadheadi.	Spines of fish.
Pleurotomaria sphærulata.	

Most of these are also included in our list from the limestone which follows.

Upper Fort Scott Limestone.—A limestone from ten to fourteen feet thick, weathering gray or buff. It is usually rather thinly bedded, and in the upper part unevenly so. It is quite rich in fossils.

Localities at which collections were made: (*a*) Cement works across the Marmaton river, and at the Minden branch Missouri Pacific railroad crossing in the west part of Fort Scott. (*b*) Just east of Santa Fe station at Girard. (*c*) In the road in a ravine two and one-half miles east of Girard. (*d*) McCune, in the edge of town just west of the creamery, railroad cut just east of the station, and two and one-half miles west of town on Mr. Welsh's place (quarry in the yard).

	a. Fort Scott.	b. Girard.	c. 2½ mi. E. Girard.	d. McCune.
Fusulinella sp	c	x	c	c
Aulopora sp	......	x	......	......
Axophyllum rude White and St. John*........	c	x	x	x
Campophyllum torquium Owen.................	x	......	......	x
Chætetes milleporaceous Edwards and Haime*,	aa	......	a	a
Lophophyllum profundum (Edwards and Haime)	x	......	......	x

	a. Fort Scott.	b. Girard.	c. 2½ mi. E. Girard.	d. McCune.
Lophophyllum westii Beede	......	......	......	x
Michelinia eugeneæ White	x	......	......	......
Erisocrinus sp	x	......	......	......
Archæocidaris sp	......	......	x	......
Serpula insista White	x	......	......	......
Fenestella limbata Foerste (*?)	x	x	x	x
Fistulipora nodulifera Meek	x	x	x	......
Pinnatopota whitei Foerste	x	......	......	x
Polypora sp.*	x	......	......	x
Prismopora triangulata White	c	.....	c	c
Rhombopora delicata Rogers	x	......	......	x
Rhombopora lepidodendroides Meek *	......	......	......	x
Stenopora carbonaria Worthen	x	x	x	......
Thamniscus ? sp	x	......	......	x
Ambocœlia planoconvexa (Shumard)*	c	......	......	x
Chonetes flemmingi Norwood and Pratten*	x	x	x	x
Chonetes mesolobus Norwood and Pratten*	c	......	......	c
Cleiothyris roissyi L'Eveillé[8]	x	?	......	x
Crania modesta White and St. John	x	x	x	x
Derbya bennetti Hall and Clarke	x	......	......	......
Derbya sp	x	......	......	......
Dielesma bovidens (Morton)	x	......	......	......
Hustedia mormoni (Marcou)*	x	x	x	x
Productus auriculatus Swallow ?	......	......	x	......
Productus cora d'Orbigny	......	......	x	......
Productus longispinus Sowerby	c	c	c	c
Productus muricatus Norwood and Pratten*	c	......	......	c
Productus pertenuis Meek	......	c	c	x
Pugnax utah (Marcou)	......	x	x	......
Reticularia perplexa (McChesney)*	a	c	c	c
Rhipidomella pecosi (Marcou)	x	......	......	......
Seminula argentia (Shepard)*	c	c	c	c
Spirifer sp	x	......	......	......
Spiriferina kentuckiensis (Shumard)	x	......	......	x
Strophalosia spondyliformis White and St. John,	......	x	......	x
Aviculopecten carboniferus (Stevens)	x	x	x	x
Aviculopecten interlineatus Meek and Worthen,	x	x	......	x
Conocardium acadianum Dawson	......	x	......	x
Conocardium parishi Worthen	x	x	x	x
Edmondia cf. aspenwallensis Meek (* ?)	x	......	......	......
Lima sp	x	......	......	......
Macrodon sp	......	x	......	......
Macrodon tenuistriata Meek ?	......	......	......	x
Pelecypod sp	......	......	......	x
Pseudomonotis sp	......	x	....	x
Schizodus wheeleri Swallow ?	x	......	......	......

8. The identification of this species in this paper is provisional.

	a. Fort Scott.	b. Girard.	c. 2¼ mi. E. Girard.	d. McCune.
Bulimorpha chrysalis (Meek and Worthen)?....	?	x	......	......
Bulimorpha sp............................	x	......	......	......
Dentalium sp.............................	......	x	x	x
Gastropods 2 or 3 indeterminable species......	......	x	......	......
Gastropod sp.............................	......	......	x	x
Platyceras sp............................	......	x	......	......
Strophostylus nanus (Meek and Worthen)......	?	x	......	x
Cephalopod sp............................	......	x	x	......
Gastrioceras ? sp........................	......	x	......	......
Nautilus planovolvis (Shumard)...............	x	......	......	......
Cypridella americana Rogers MSS............	c	c	c	c
Cypridina sp.............................	x	c	x	x
Cypridinella sp..........................	......	x	x	x
Cyclus sp................................	x	......	......	......
Cyclus packardi Rogers....................	......	......	x	......
Griffithides scitula (Meek and Worthen)	c	c	c	c
Griffithides sp...........................	......	......	c	......
Psammodus sp	x	......	......	......

Girty refers the following additional species here without locality:

Fusulina cylindrica.
Syringopora ? sp.
Meekella striaticostata.
Productus semireticulatus.
Productus sp.
Productus punctatus.
Marginifera wabashensis.
Cleiothyris orbicularis.
Aviculopecten occidentalis.
Euchondria neglecta.
Ostracoda (probably included in above list).

Doctor Bennett gives twenty-eight species from the Upper Fort Scott limestone, at Fort Scott, about fifteen of which are not mentioned in our list from this horizon.[9]

LABETTE SHALES.

Thirty-five to fifty feet of bituminous, calcareous and arenaceous shales with, locally, some fossils.

Our specimens were taken from practically two localities: (*a*) At Fort Scott, one mile east of the city and one and one-half miles southwest of the city, near the Minden branch of the Missouri Pacific railroad. (*b*) One and one-half miles southwest of Laneville, on Alexander Slain's place.

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9. Zaphrentis gibsoni ?
Discina nitida.
Streptorhynchus crassus.
Aviculopecten sp.
Nucula ventricosa.
Nuculana bellistriata.
Bellerophon carbonaria.
Bellerophon percarinatus.
Bellerophon sp.
Euomphalus rugosus.
Loxonema rugosa ?.
Loxonema intercalaris.
Naticopsis altonensis.
Pleurotomaria sp.
Goniatites sp.
Scales, dermal plates and spines of fish.

	a. Fort Scott.	b. Laneville.
Lophophyllum sp.*	c	......
Stenopora carbonaria (Worthen)	x	......
Ambocœlia planoconvexa (Shumard)	c	......
Chonetes granulifer Owen?	x	......
Chonetes mesolobus Norwood and Pratten*	a	x
Derbya crassa (Meek and Hayden)*	a	......
Orbiculoidea missouriensis (Shumard)	a	a
Productus cora d'Orbigny	c	......
Productus longispinus Sowerby	c	......
Productus muricatus Norwood and Pratten	c	......
Productus nebrascensis Owen	x	......
Rhipidomella pecosi (Marcou)	......	x
Seminula argentia (Shepard)	c	c
Astartella sp.	x	......
Aviculopecten rectilaterarius Cox	......	x
Edmondia sp.	x	......
Myalina swallowi McChesney	x	?
Nucula ventricosa Hall*	......	c
Nuculana bellistriata attenuata Meek	......	c
Aclisina minuta (Stevens)	......	x
Pleurotomaria sp.	......	x

Girty refers *Rhombopora lepidodendroides* to this horizon.

PAWNEE LIMESTONE.

A heavy stratum of limestone thirty-five or more feet in thickness, resting on the Labette shales. The base of the limestone is often a dark buff or even a chocolate-brown color, while the stone above is very much lighter. That part of the layer resting on the browner-colored rock is frequently very coarsely brecciated, the individual fragments frequently reaching an inch or more in diameter. At Farlington this brecciated portion is about ten feet thick. Over the breccia is another massive limestone. Most of our fossils were taken from the lower part of the formation.

The localities were as follows: (*a*) Just north of the National cemetery, southeast of Fort Scott. (*b*) Bridge over Marmaton river, one-half mile south and one and one-half miles west of Marmaton station. (*c*) Farlington, northeast of the station, on the little creek. (*d*) One and one-half miles northwest of Girard, on S. S. Gruber's place. (*e*) One mile southwest of Laneville, on Alexander Slain's place.

	a. Fort Scott.	b. Marmaton.	c. Farlington.	d. Girard.	e. Laneville.
Fusulinella sp	c	c	x	c	a
Amblysiphonella? Bryozoan?	x	......	......	......	a
Aulopora sp	......	x	......	......	.....
Axophyllum rude White and St. John,	x	x	x	......	x
Axophyllum sp	......	c	c	......	.....
Campophyllum torquium Owen	......	......	x	x	.....
Chætetes milleporaceous (Edwards and Haime)*	a	......	a	a	.....
Lophophyllum profundum (Edwards and Haime)*	x	c	......	......	x
Lophopyllum? sp*	......	......	x	......	.....
Lophophyllum westii Beede*	......	a	.....	......	a
Michelinia eugeneæ White	......	x	......	......	c
Archæocidaris sp	......	......	......	......	x
Chainodictyon laxum Foerste	x	......	......	......	x
Fenestella limbata Foerste	x	......	c	x	c
Fenestella sp	......	......	x	......	x
Fistulipora nodulifera Meek	c	c	c	x	c
Pinnatopora sp	c	......	......	......	.....
Pinnatopora whitei Foerste	c	......	......	x	.....
Polypora elliptica Rogers	c	......	......	......	c
Polypora sp	......	......	......	......	x
Prismopora triangulata White	x	......	x	......	.....
Rhomboeladia delicata Rogers	c	......	......	x	c
Rhombopora lepidodendroides Meek	......	......	......	......	x
Stenopora carbonaria (Worthen)	......	x	......	......	.....
Ambocœlia planoconvexa (Shumard)*,	c	c	c	......	c
Brachiopod? sp., a bazarre form	......	......	......	......	c
Brachiopod sp., perhaps a productoid	......	......	......	x	......
Chonetes flemmingi Norwood and Pratten*	c	x	......	x	x
Chonetes mesolobus Norwood and Pratten	x	......	......	x	x
Cleiothyris roissyi L'Eviellé (*?)	x	a	......	......	x
Crania modesta White and St. John	x	......	x	x	x
Cryptacanthia compacta White and St. John	c	c	......	......	......
Dielasma bovidens (Morton)	......	x	x	......	x
Hustedia mormoni (Marcou)*	c	a	c	x	c
Meekella striaticostata (McChesney)	......	......	x	......	......
Orthotetes sp	......	......	x	a	......
Productus cora d'Orbigny	......	......	......	......	x
Productus costatus Sowerby	x	......	x	......	x
Productus longispinus Sowerby (*?)	c	c	c	x	c
Productus muricatus Norwood and Pratten	x	x	x	......	......
Productus pertenuis Meek	x	......	c	x	x
Productus semireticulatus (Martin)*	......	......	c	......	......

	a. Fort Scott.	b. Marmaton.	c. Farlington.	d. Girard.	e. Laneville.
Productus sp	......	x	c	......	......
Proboscidella? sp	......	......	x	......	......
Reticularia perplexa (McChesney)*	a	aa	a	c	a
Rhipidomella pecosi (Marcou)*	x	......	......	......	x
Seminula argentia (Shepard)*	c	c	a	......	c
Seminula subquadrata Hall ?	x	......	......	......	......
Spirifer cameratus Morton	x	x	......	......	......
Spiriferina kentuckiensis (Shumard)	x	......	......	......	x
Strophalosia spondyliformis (White and St. John)	......	......	c	......	x
Aviculopecten carboniferus (Stevens)	......	......	x	x	......
Aviculopecten interlineatus Meek and Worthen	......	......	x	x	......
Aviculopecten? sp	......	......	x	x	......
Clinopistha radiata Hall?	......	......	......	......	x
Conocardium parishi Worthen	x	x	x	x	......
Conocardium sp	x	......	......	......	......
Macrodon sp	x	......	......	......	......
Macrodon? sp	x	......	......	......	......
Myalina swallowi (McChesney)	......	......	x	......	......
Pelecypod sp	......	......	x	......	......
Anomphalus sp	x	......	......	......	......
Bellerophon carbonarius Cox	......	x	......	......	......
Bellerophon sp	......	......	x	......	......
Capulus parvus Swallow	......	x	......	......	......
Euomphalus sp (*?)	......	......	x	......	......
Gastropod sp	x	......	......	x	x
Naticopsis sp	......	......	x	......	......
Pleurotomaria missouriensis Swallow	......	......	x	......	......
Pleurotomaria sp	......	x	......	......	......
Pleurotomaria tabulata (Conrad)	x	......	......	......	......
Straparollus? sp	x	......	x	......	......
Cephalopod sp	......	......	x	......	x
Orthoceras sp	......	......	x	......	......
Cyclus pyrimidatus Rogers	......	......	......	x	......
Cypridella americana Rogers MSS	x	......	x	x	x
Cypridina sp	x	......	x	x	......
Euotmis curvisulcata Rogers MSS	......	......	......	x	......
Griffithides scitula Meek and Worthen	......	......	......	......	x
Fish tooth and spines	x	......	......	......	x
Peripristis semicircularis	......	x	......	......	......

Girty also refers *Fusulina cylindrica* and *Syringopora ?* sp. to this horizon.

Doctor Bennett (loc. cit.) reports the following additional species from the Pawnee limestone, at Fort Scott:

Zeacrinus mucrospinus.
Discina nitida.
Naticopsis ventricosa.
Pleurotomaria sphærulata.

BANDERA SHALES.

About 100 feet of shales and sandstone flagging. The only fossils seen were crustacean tracks and what appear to be large worm tracks in the flagging in Mr. Gilfillan's quarry west of Redfield.

ALTAMONT (PARSONS) LIMESTONE.

A six- or eight-foot stratum of limestone resting on the Bandera shales. This limestone was very poorly fossiliferous at the localities visited.

The localities were: (*a*) Bed of the Marmaton river a mile east of Uniontown and at Gilfillan. (*b*) Two miles east and a half-mile south of Walnut, in the road by the railroad-crossing.

	a. Uniontown.	b. Walnut.
Fusulinella sp	......	a
Axophyllum rude White and St. John	x	x
Lophophyllum westii Beede	x	x
Crinoid sp. (* ?)	......	x
Archæocidaris sp	......	x
Spirorbis sp	x	......
Fistulipora nodulifera Meek (* ?)	......	c
Pinnatopora sp	......	x
Polypora sp	......	x
Rhombopora delicata Rogers	......	c
Ambocœlia planoconvexa (Shumard)*	c	c
Cleiothyris roissyi L'Eveillé*	x	x
Chonetes mesolobus Norwood and Pratten*	......	x
Cryptacanthia compacta White and St. John	x	......
Hustedia mormoni (Marcou)*	c	x
Orbiculoidea missouriensis (Shumard)*	a	......
Orthotetes sp	......	x
Productus longispinus Sowerby (*?)	a	c
Productus semireticulatus (Martin)*	......	x
Productus? sp	......	x
Pugnax utah (Marcou)*	x	......
Reticularia perplexa (McChesney)*	aa	a
Seminula argentia (Shepard)*	a	c
Spirifer cameratus Morton*	......	x
Myalina sp	x	......
Bellerophon sp. (*?)	x	......
Gastropod sp	x	......
Strophostylus sp	x	......
Fish spines and tooth or tubercle	x	......

Girty's list contains the following additional species, with no locality given:

Sponge?	Pugnax rockymontana.
Lophophyllum proliferum.	Pleurotomaria sp.
Chætetes milleporaceous.	Pleurophorus sp.
Campophyllum sp.	Astartella vera.
Stenopora sp.	Leda bellistriata.
Cladopora sp.	Nucula ventricosa.
Prismopora serrata.	Orthoceras rushense?.
Fenestella sp.	Dentalium? sp.
Chonetes glaber.	Naticopsis sp.
Chonetes flemmingi.	Euomphalus subrugosus.
Derbya crassa.	Phanerotrema grayvillensis.
Dielasma bovidens.	Worthenia tabulata.
Meekella striaticostata.	Trepospira sphærulata.
Productus nebrascensis.	Euphemus carbonarius.
Productus punctatus.	Soleniscus sp.
Spiriferina kentuckiensis.	Bellerophon crassus?.

Doctor Bennett adds *Petrodus occidentalis* to the list from this limestone.

DUDLEY SHALES.

About 159 feet of shales with thin limestones and sandstones. We collected no fossils from these shales.